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RAW *versus* PASTEURISED MILK

IN view of the importance of this question to agricultural producers, public health authorities and the general body of consumers, the Department requested a number of eminent medical and other scientific men to contribute short atricles summarising their views on the subject. Their contributions are printed, each under its author's name, on this and the following pages, and the Department acknowledge gratefully the ready response which all these writers made to their request. Previous articles on the subject were contributed by Dr Sprawson to the *Journal* for January 1933 and by Dr Chalmers Watson to the *Journal* for October 1933.

W. L. BURGESS, M.D., D.P.H.

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I am of opinion that all milk not produced and sold under licence as Certified or Grade A (Tuberculin Tested) should be pasteurised. This conclusion has been arrived at after careful consideration of the views of authorities on the subject. It is also based to some extent on my own experience. There are times when I incline to the view that all milk, even the high grade milks, should be pasteurised, but it has to be admitted that the available evidence does not fully support such an extreme attitude. It is the aim of every health authority to ensure, so far as possible, that milk distributed for human consumption is entirely free of pathogenic organisms, and has its nutritive qualities unimpaired. At the present time that aim is impossible of achievement in the absence of a system of pasteurisation.

Space forbids a full description of the many issues, and I can only summarise the arguments which have influenced my conclusions. For convenience, these are divided into two groups: (1) the desirability of pasteurising all milk, which is not produced and sold under licence as Certified or Grade A (Tuberculin Tested), and (2) the practicability of such a procedure.

(1) *Desirability.*—Milk is responsible for the spread of various infections. These are too well known to require detailing here.

In Dundee during the last fifteen years, we have records of some nine outbreaks of milk infection, in which the evidence supports the conclusion that the disease was spread by ordinary unpasteurised milk. There are no records of any outbreaks in Dundee being caused by pasteurised milk, although for some years about 45 per cent. of the milk supply has been pasteurised.

The more rapid decline in the death-rates from non-pulmonary tuberculosis in Dundee compared with that from pulmonary tuberculosis contains at least the suggestion that the increasing practice of pasteurising milk may have had an influence.

The bovine tubercle bacillus is responsible for a definitely measurable proportion of the total of human tuberculosis.

There is a mass of evidence in support of the view that, in practically all cases, the bovine organism enters the body in milk.

A very definite proportion of milk samples contain tubercle bacilli.

The percentage of cows infected with tuberculosis in this country is very high.

There is little evidence that bovine tuberculosis is declining.

The rapid elimination of bovine tuberculosis would be too costly and would endanger the milk supply.

It has not been proved that pasteurisation reduces to any extent the nutritive value of milk. Any effect of this sort can be easily compensated, and is so trifling that it cannot be set against the undoubted advantage of a safe milk.

There is ample proof that pasteurisation, carefully carried out, destroys the tubercle bacillus. As carried out in practice, the percentage of positive samples is very much smaller in pasteurised than in ordinary milk.

There is also ample proof that the process destroys the organisms responsible for the acute infections.

There is evidence that where pasteurisation is in general use, the incidence of bovine tuberculosis in the human subject is low.

(2) *Practicability.*—While I have no doubt whatever of the desirability of pasteurising ungraded milk, I admit that there would be difficulties in putting such a proposal into practice. Nevertheless, I am convinced that the obstacles are not by any means insurmountable, and that they are small compared with those which will have to be overcome in order to eradicate tuberculosis entirely from dairy herds in this country. Such eradication must, of course, be the ultimate aim, but, meantime, pasteurisation should be adopted as a preventive measure, pending the disappearance of bovine tuberculosis.

The introduction of a system of compulsory pasteurisation of milk, other than the two grades mentioned, would undoubtedly upset the small business of milk production and handling. Such

a producer would not find it economically sound to instal a pasteurising plant, and he would have to sell his milk to a dealer in a large way, arrange for such a dealer to pasteurise his milk, or co-operate with his fellows in the establishment of a suitable plant. The only other possibility would be for the small producer to satisfy the necessary requirements and obtain one or the other of the high-grade licences. The time is overdue for the reorganisation of his business by the small milk trader. The increasing tendency to bulk milk is not entirely the result of the practice of pasteurisation. The heating process has rather followed the bulking process for commercial reasons, and for public health reasons, as infection in any small consignment of milk is thereby transferred to a large volume. The centralisation of milk distribution seems to be inevitable, and irrespective of a policy of compulsory pasteurisation, the small producer may have to change his methods.

Compulsory pasteurisation is a very fair compromise which, by rendering milk safe immediately, would enable a sane policy of bovine tuberculosis eradication to be devised and applied. In my view, pasteurisation would materially assist the working out of such a policy, but the dairyman must be given sufficient time to make his arrangements, and the exercise of the proposed powers on a regional basis is advisable.

A. K. CHALMERS, M.D., LL.D.

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A FEW illustrations may serve to focus attention on some of the conditions under which there may arise certain diseases—for convenience now called "deficiency" diseases because they arise from the absence, from an otherwise ample dietary, of certain "accessory food substances." These are called vitamins, but at the beginning of the century they were unknown.

I. When Captain Scott led his first expedition towards the South Pole the experience of Arctic explorers and of those on long sea voyages had demonstrated that scurvy was "an especial scourge to those who by force of circumstances have been deprived of fresh food for any length of time."[1] In consequence, the expedition was provisioned on a scale adequate, according to the knowledge of the time, to maintain the health and efficiency of its members during periods of strenuous effort, in places where ready supplies of fresh food would not be obtainable. Despite this care in the selection of food, scurvy was detected among the members of one of the early sledging parties, and subsequent examination disclosed it also among some of those on board the *Discovery* in winter quarters.

The first steps taken were to serve out fresh (seal) meat regularly and to double the allowance of bottled fruit. As seals became more accessible, no tinned meat of any description was issued, and with

[1] *The Voyage of the "Discovery,"* vol. i., p. 548.

returning daylight mustard and cress were sown. Scott was still apprehensive that scurvy might return to future sledging parties, as indeed it did. So convinced was he of the "inestimable advantages" of fresh food that when the disease again appeared in the sledge party he himself led towards the Pole, he writes: "We have decided to cease using our bacon and to increase the seal allowance, as the former seems the more likely cause of the scurvy symptoms." This was in 1902.

II. Thirty years later, Dr F. John Poynton, Senior Physician to the Hospital for Sick Children, Great Ormond Street, in a letter to the *British Medical Journal* of 21st October 1933, says, with reference to infantile scurvy: "On former occasions I have alluded to my belief that this condition seemed to me to be on the increase. Now, for the first time in my years of hospital life, I have had three cases at the same time in my ward (at Great Ormond Street). This seems remarkable when we realise the great work that has been done in vitamins, and when we perhaps look upon the position of vitamin C as one of the best understood among them. . . . As regards infantile scurvy, I am not prepared to do more than direct attention to the vast quantities of dried milk now in use, and to raise a question which I have raised before, whether such foods, even given with precaution, make for the best constitution in years to come. We know that some children do not take fruit juices well, or are thought not to take them well, and these are then discarded; and should infantile scurvy really be on the increase, and my experience not be only a hospital coincidence, it is clear to me that many diets must touch the border-line of pathological metabolism."

Both incidents have a bearing on the question under discussion. Vitamins were unknown in 1902, and dried milk only came into extensive use late in the second decade of the present century.

III. A further step was reached during the development of the Maternity and Child Welfare Movement, which began in an effort to reduce the number of deaths occurring during the first year of life. In consequence, the artificial feeding of infants acquired a new emphasis. Should cow's milk be boiled (brought to the boil) and rapidly cooled before being fed to infants who could not be breast-fed? Was its nutritive value thereby impaired? These and like questions were engaging the attention of those interested in the movement, and coincidentally the Medical Research Committee (now Council), which was just beginning to function when the War began, included the subject of milk in relation to public health within the scope of its researches. On their invitation, Dr Jane Lane-Claypon reviewed the evidence then available and reported in 1916.[1]

Reviewing the clinical data on the nutritive value of raw and boiled cow's milk as a food for infants (Chapter XI) she writes:

[1] *Milk and its Hygienic Relations*, published under the direction of the Medical Research Council (National Health Insurance).

"The investigations which have been described in detail (in this chapter) show that milk used for the feeding of infants may be raised without disadvantage for a short, or even a prolonged period, to a temperature which is approximately 100° C. or 212° F. . . . The conclusion which may be fairly made is that milk, when used as a food in the home, may be heated to 100° C. approximately without any detrimental effect. Such heating, moreover, acts as an efficient safeguard against the causation of disease by harmful organisms accidentally present in the milk" (page 290).

IV. The foregoing observations apply to the preparation of milk for infants in their own homes. At that time the commercial pasteurisation of milk as at present understood may be said to have been in its infancy, in this country at least, although it was being largely practised in America. Both the "Holder" and "Flash" processes were known, and *Bulletin No.* 5 *of the Hannah Dairy Research Institute*, referred to in Dr Chalmers Watson's article in the October issue of this *Journal*, contains a critical review of the available evidence regarding the effect of the "Holder" process on the nutritive value of milk. It will therefore be sufficient for the present purpose to quote two extracts from Chapter VI of the *Bulletin.*

Dealing in the first place with children "who depend for their energy intake mainly on sources other than milk," the authors say: "Under these circumstances there do not appear to be any good grounds for the belief that pasteurised milk is a less valuable component of the diet than raw milk *for children who satisfy the bulk of their nutritive requirements from sources other than milk.* . . . The position with regard to infants subsisting on complete diets of cow's milk cannot be regarded as equally satisfactory. . . . It has been established by Daniels and Stearns that the capacity to retain calcium and phosphorus from diets of pasteurised milk is less than from diets of quickly boiled milk." And they conclude: "There are, therefore, strong grounds for the belief that infants can satisfy all their requirements on diets of adequate amounts of pasteurised milk, *provided that extra vitamin D and, of course, vitamin C* are added to the diet."

The question here raised very acutely is the unsuitability of pasteurised milk as a diet for infants unless supplemented by vitamins C and D from other sources, and one inevitably recalls Dr Poynton's observations, quoted in a previous paragraph: Risks of infantile scurvy and rickets for the on-coming generation are not to be lightly incurred in the search after a safe and wholesome milk supply. What seems to be sharply raised by the contrasted results of Dr Lane-Claypon's inquiry and those reviewed in *Bulletin No.* 5 *of the Hannah Institute* is whether prolonged exposure to a lower temperature (as in the "Holder" process) is not more injurious to the vitamin content of milk than the short-time exposure to boiling point, as is the domestic habit. Earlier in *Bulletin No.* 5,

indeed, the effect of both these processes on the calcium-phosphorous balance in milk is considered.

The Implications of Compulsory Pasteurisation.—In view of the findings narrated in the preceding paragraphs, it is important to note that pasteurisation proposals make no provision for milk suitable for infants. All milk placed on the market for sale is to be pasteurised, save that which is obtained from tubercle-free herds. There is evidence that pasteurised milk, reheated in the home for infant feeding, has been followed by infantile scurvy (*Medical Research Council's Vitamin Report*, 1932, and *Bulletin No.* 5), unless care is taken to restrict the second heating to a temperature not higher than about blood heat.

Moreover, no suggestion is made that milk produced under conditions so graphically described in Mr Ben Davies's[1] pamphlet on *The Nation's Milk Supply*, issued in July last, will be excluded. The interest here lies in the recognition of the fact that thermoduric organisms which flourish at the temperature of pasteurisation and are present in all dairy equipment which is not effectively sterilised, from the milking machine to the milk can, are without any known significance for human health, but are detrimental alike to the keeping quality and perfect flavour of milk. Mr Davies's plea for a clean milk supply reached through the sterilisation of equipment is irresistible.

Differential Legislation.—Two observations seem relevant on this aspect of the proposal to pasteurise compulsorily part only of any article of food placed on sale.

In the first place, it is differentiation against the poorer consumer, a principle hitherto unknown in public health legislation. The sale of certified and other tuberculin-tested milks proclaims the production of a pure milk supply as possible. And if we are to accept pasteurisation as an administrative principle, it will be impossible logically to continue opposing the introduction of sterilised portions of tuberculous carcases.

Bulking.—There is an accumulating mass of evidence pointing to the widespread deterioration of the quality of market milk caused by the modern practice of bulking.

The recent report by the Department of Health for Scotland on "Tuberculous Infection in Milk" (*Medical Research Council's Special Report Series, No.* 189) makes this abundantly clear.

Raw milk conveyed in churns from "producer" farms was found to yield tubercle in an average of 10 per cent. of the samples taken. On the other hand, when "special inquiry was made of the amount of tuberculous infection in creamery bulked milk sent to cities in tanks . . . of the total samples 37·5 per cent. were found to be infected, the incidence therefore being between three and four times the general figures given previously for raw market milk" (pp. 15-16).

It is unnecessary to assume that any of the herds whose milk

[1] Director of Laboratories, etc., United Dairies, Ltd.

was thus "bulked" had a higher rate of incidence of tuberculosis than the individual herds whose milk was forwarded in churns. But bulking gives tuberculous milk the opportunity of a wider distribution.

There is a marked family resemblance between the problem created by bulked milk and that presented by consignments of frozen boneless meat before the introduction of Regulations under the Act of 1907. In this instance the difficulty lay in tracing the source of origin. So with the tubercle content in bulked milk. Boneless meat was detached from every anatomical landmark by which it might be identified—bulked milk comes from many herds; and the detection of the particular herd or animal contributing its quota to the added 27·5 per cent. above the infection rate of "churn" milk might well tax the resources of the most efficient administration. But a beginning would be made were regulations introduced prohibiting the bulking of milk for domestic use and particularly for infant feeding, save that obtained from tubercle-free herds, under a system of housing and management directed to the production of clean milk. The delinquent herds would then be brought into the open. Although tubercle bacilli do not multiply in milk during transit, they may retain their virulence for such a period as would render milk unusable if kept under ordinary domestic conditions; and the distribution of infected milk through the volume of bulked milk reduces the proportion of tubercle-free milk from an average of 90 to little more than 60 per cent.

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In order to answer intelligently the question, Is pasteurisation of milk advisable? it appears to me that there are certain points which should be made definitely clear.

(1) Does ordinary milk contain the bacillus of tuberculosis? The answer is "Yes." Recent work done by the Bacteriological Departments of four large cities in Scotland showed that tubercle bacilli were present in 10 per cent. samples of milk and in "bulked" milk 33 per cent. approximately.

(2) The next question naturally follows: Is the presence of tubercle bacilli in the milk a danger to the consumer? The number of bacilli in milk is not of very great importance to adults, although it is a danger, but to children the danger is much more marked. In Edinburgh we have regularly in hospital about 75 patients suffering from non-pulmonary tuberculosis, namely, tuberculosis of bones, joints, etc., and in many of these the causal germ is the tubercle bacillus found in milk. In Scotland it is reckoned that at least 1000 children die annually as a result of tuberculosis due to the bovine variety.

(3) The next point which should be made clear is, admitting

that these germs sometimes do harm: Is there another side to the question, namely, do they accomplish any good? Statements have been made that the repeated small doses of tubercle bacilli which we get in milk produce in the general public a resistance to the disease, and such a resistance that, in adult life, if a patient contracts tuberculosis of the lung, it is rarely of the acute galloping type, but is a much slower chronic form. This statement as to increasing resistance or immunity is purely problematical, as we know very little about it, but the danger to children from tuberculous milk is not problematical; it is very real.

(4) Another question to be answered is: Does milk form a ready medium for conveying the causal organisms of other infectious disease? Again the answer is "Yes." Many an outbreak of scarlet fever, diphtheria, typhoid fever, etc., has been traced to contaminated milk.

It appears to be established beyond doubt that milk is capable of conveying the germs of several diseases.

(5) The next point to be determined is: Does pasteurisation kill these germs, and will pasteurisation make milk safe? The answer is under laboratory conditions "Yes," but in the investigation by the four large cities already alluded to, milk which had been pasteurised showed the presence of tubercle bacilli in 2·8 per cent. of the samples examined. The causal organisms, however, of scarlet fever, typhoid and diphtheria, etc., are destroyed by pasteurisation, so that from the point of view of the prevention of the spread of disease, pasteurisation has a strong case for recommendation

(6) The next important point to be settled is: Does pasteurisation interfere with the nutritive qualities of the milk? The answer is, I think, "Yes," but the amount of damage is so slight as to be negligible. The only exception which might be made here would be for children fed on milk only. In the case of the poor, whose supply of calcium and vitamins in their ordinary diet is poor, it may be that there is a deprivation of these elements in milk by pasteurisation which is not warranted. It is all the more important as milk is the only uncooked food used. In the case of elder children and adults living on a good mixed diet, the amount of alteration in the nutritive quality of the milk is not worth mentioning.

(7) The last point to be discussed is: What effect will compulsory pasteurisation have on numbers of milk-producing farms? It is often stated quite correctly that pasteurisation, although it kills infecting organisms, does not make clean milk. Hence by some method of reasoning, which I find myself incapable of understanding, it is stated that pasteurisation will make the farm workers careless as to the cleanliness of their milk. They can produce milk as dirty as they like and have an excuse that "it is going to be pasteurised, anyway, so it doesn't matter."

Pasteurisation will not abolish, nor even hinder, the activities of the Health Departments in their endeavour to produce clean

milk. Indeed, if it be applied extensively, pasteurisation will in all probability be carried out by large firms, possibly under the supervision of the Health Authorities, and these large firms will undoubtedly have a preliminary examination of the milk to detect the extent of contamination by visible dirt. Should a farmer be found to be sending samples of milk in which dirt is at all marked, he would certainly be warned that if he did not produce cleaner milk his supply would be refused. Consequently I am of opinion that if pasteurisation were made compulsory, the general trend of milk cleanliness would be upwards.

Pasteurisation should be looked on as a temporary expedient until the dairy herds can be cleared of disease, for the ideal milk appears to me to be milk from cows free from tuberculosis, contagious abortion, or other disease, produced under hygienic conditions and bottled on the farm. Compulsory pasteurisation of all milk sold in this country is not practicable ; nor considering the present state of our knowledge is it desirable. What should be done is to give our city authorities powers to apply such a measure to their own area if they so desire. To this there should be added also the power to insist that all milk pasteurised should, when sold, be labelled accordingly.

SIR A. D. HALL, F.R.S.

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THE value of pasteurisation as a means of ensuring that the supply of milk to the general public shall be safe and free from the risk of transmitting epidemic disease, requires consideration from a broader point of view than that of the absence of dangerous bacteria from a given sample. We know, of course, that the bacilli of bovine tuberculosis are present in the milk of cows in an ordinary untested herd, and that tubercular affections, even death, do arise from the consumption of such milk by young children. Undulant fever, caused by the organism producing contagious abortion in the cow, is also a danger, and from time to time milk does become a carrier of other diseases, like scarlet fever, with which one of the attendants of the cows may be suffering. From these dangers pasteurisation, if properly carried out, offers an easy and inexpensive protection, and one cannot wonder that many medical officers, obsessed by the cases of preventable disease which are forced upon their notice, turn to pasteurisation as the readiest road to safety.

The good is ever enemy to the best, and I fear that universal pasteurisation might indefinitely defer the real desideratum—the cleaning up of the dairy herds of the country and the elimination of bovine tuberculosis. Pasteurisation does add an element of cost to the milk supply, and does introduce dangers of its own if imperfectly carried out or if the milk is contaminated with certain dirt organisms that are heat-resisting. Whether in pasteurised milk

certain of the obscure elements of nutrition have been destroyed, thus making it of inferior nutritive value for children, is still a matter of dispute, though all general considerations are on the side of fresh milk.

It is, however, certain that of recent years great improvements have been made in the general cleanliness and quality of the milk supply, and the danger is that such progress will be checked when it begins to be thought that precautions need no longer be taken because the milk will be cleaned up by the pasteurising process. It is just for this reason that preservatives have been forbidden in milk and other foods. They will defer or even inhibit the development of sourness or putrefaction, and thus serve as a cloak to cover dirty methods of preparation. In the same way in America public water supplies are very generally chlorinated to remove the risk of the dissemination of typhoid, etc., but this puts out of mind the vital necessity of securing an uncontaminated water supply.

It has become practicable to eliminate bovine tuberculosis from our herds, and though it would be a matter of time and considerable expense, the outlay would be well repaid both by the longer working life of the dairy cows and by the increased confidence of the public in the use of milk. The consumers would eventually gain if this cleaning up were effected, for thereby the cost of milk production would be brought down; at the same time the farmers would no longer find the doctors diverting consumers from fresh to dried milk.

Let us not therefore interpose a delay in setting about this necessary reform by introducing the palliative with which we should afterwards be disposed to rest content.

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THE Editor has asked me to summarise, as briefly as possible, the known facts. I hope it will be felt that in the following epitome I have succeeded in giving a fair and unbiased interpretation of the available evidence.

1. *The Problem to be Faced.*—A considerable proportion of milk sold in this country is infected with tubercle. It is established that much tuberculosis in human beings is of bovine origin. (To a less important extent also other infections may sometimes be milk borne.) What is the remedy?

2. *The Alternative Remedies.*—A number of alternative solutions are possible:

(*a*) The ideal course, and the most effective, would be bold administrative action—admittedly at great expense—to discover and to eradicate all known tainted sources.

(*b*) A less radical policy is to encourage by all possible means

the more general use of certified milk (and to help to make its use financially possible to those who need it).

(c) The introduction of compulsory pasteurisation. Milk that has been pasteurised, provided the correct type of procedure has been adopted, is free from the "t.b." risk. It is likely, however, to be inferior to raw milk in its vitamin C potency, and possibly also (though probably to a less important degree) in certain other nutritive properties. If universal pasteurisation is enforced, therefore, it seems to me that it becomes more necessary than ever for public health organisations to undertake widespread propaganda to get it more generally realised that supplements of orange juice (as also of vitamin D) are essential for all young infants—a fact which is already recognised by the principal pædiatric authorities.

I would regard pasteurisation, then, as in a sense only a makeshift device, as a palliative in the absence of more thoroughgoing measures; but rather than spread disease by infected milk I cannot doubt that it is better to suffer some relatively slight loss of nutritive properties, which, as evidence indicates, can be largely rectified by quite simple means.

Effect of Pasteurisation on Nutritive Value of Milk.—1. Vitamin C. It is admitted that the vitamin C value of the milk may be considerably diminished by pasteurisation, but experience shows that raw milk itself is never a really reliable source of this factor, and ought in any case to be supplemented with fruit juice.

2. Various negative results. Apart from the vitamin C question there is no conclusive evidence, in my opinion, that other nutritive properties of the milk are affected to any serious degree. Many investigations have indeed been carried out which have only served to show the absence of any ill-effect on various specific factors. These papers are too numerous to specify here *seriatim*, but it will be sufficient to refer to one of the most recent and most thoroughgoing surveys, that by Stirling and Blackwood, who after a detailed discussion conclude that "there are strong grounds for the belief that infants can satisfy all their requirements on diets of adequate amounts of pasteurised milk provided that extra vitamin D, and, of course vitamin C, are added to the diet."

3. Sprawson's results. Much of the evidence obtained from past work is admittedly generally of a merely negative kind. One of the few concrete suggestions of a possible special virtue in raw over pasteurised milk is that of Sprawson, who noted a remarkably low incidence of dental caries, or a low rate of spread of the disease, in children receiving raw milk. I am not one of those who seek to minimise the undoubtedly striking nature of Sprawson's observations, but it seems to me that in the absence of any special direct controls on pasteurised milk, it is not possible to say that the effect was due for certain to the milk being raw. (Dr E. W. Fish, Director of the Research Laboratory of the Royal Dental Hospital in London,

tells me that in his experience the exclusive use of raw milk by no means always leads to the enviable results seen by Sprawson.)

4. Other Nutritive Properties. It may be true that there is some relatively slight effect on certain other properties of the milk, *e.g.*, that the availability of the lime salts, or the calcifying power of the milk, is less by, shall we say, 10 per cent. The conclusion seems inevitable, nevertheless, that it would be better to have to give one-tenth more milk in order to produce the same effect, rather than risk infection. And indeed all such changes seem of a minor character, quantitatively speaking.

Further Observations on Pasteurisation.—One point not often realised by public health workers is that a major reason why pasteurisation is so popular with many of the dairying interests, is because pasteurised milk "keeps" longer, and can therefore be sold when staler. I could myself tell lurid tales of war-time conditions under which milk was pasteurised several times over at intervals in order to keep it marketable. Let those in authority be aware of the possibility of misuse of this gift of pasteurisation!

As a matter of general interest it may be mentioned that it seems likely that in the course of another year or two conditions will have been worked out under which it will be possible to pasteurise milk without destroying the vitamin C—the conditions including, *e.g.*, exclusion of all traces of copper from the apparatus, and of light. However, let it be emphasised again that it is unsafe in any case to rely on raw milk itself as a fully adequate source of vitamin C.

Conclusions.—1. Pasteurisation, while it fails to get to the root of the trouble, is better than the sale of infected milk—but if pasteurisation is made compulsory, in the absence of more energetic measures, let it at the same time be shouted from the housetops that "all babies need orange juice."

2. Compulsory pasteurisation must not be allowed to lead to any relaxation of the efforts to procure a cleaner milk supply.

A. S. M. MACGREGOR, M.D., D.P.H.

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THE evidence which may be advanced in favour of pasteurisation as a public health policy rests upon the known capacity of this procedure, if properly carried out, to prevent the transmission of certain infectious diseases to the consumer. Infections transmissible by milk may be derived from (*a*) human, or (*b*) bovine sources. The former group includes the commoner infectious diseases such as scarlet fever, diphtheria, enteric or paratyphoid fever, and epidemic sore throat. The latter group includes the infections caused by the bovine tubercle bacillus and, much more rarely, undulant fever.

The experience of larger centres of population shows that such instances of epidemic milk-borne infections as occur are entirely

concerned with that portion of the milk supply not subjected to pasteurisation. For instance, the epidemiological history of milk-borne infections in Glasgow permits of the conclusion that pasteurisation can be definitely relied upon to protect the consumer from these infections should they have gained access to a particular milk supply. One of the practical difficulties met with in controlling milk infection, and in tracing its source, is the fact that in large centres of population purveying of milk has become more and more concentrated in the hands of large distributors, supplies from numerous farms being mixed in wholesale fashion, a procedure which increases the possibilities of spread of infections such as those instanced above. Under these circumstances, the practice of pasteurisation is an efficient safeguard and possesses great practical advantages.

As regards bovine tuberculosis, it is known that raw milk, as supplied to the four large cities of Scotland by road or rail, contains living bovine tubercle bacilli to the extent of from 10 to 14 per cent. of samples taken from the complete consignments of individual farms.[1] Further, the mixing, or bulking, of milk from several farms for commercial purposes increases the volume of milk throughout which the presence of tubercle bacilli may be demonstrated. For instance, Dr Jordan, of the Hannah Dairy Research Institute, has investigated the milk of creameries, and finds that 37·5 per cent. of the samples examined were found to be infected. This again demonstrates the danger of the practice of bulking milk from the point of view of the public health. On the other hand, it has been proved that pasteurisation of milk by the "Holder" process, *i.e.* exposure to 145° F. for thirty minutes, *if properly carried out*, is an efficient method of destroying the tubercle bacillus in milk.

The public health considerations which arise may be exemplified by the following data. The investigations of Dr W. S. Blacklock, carried out in the Royal Hospital for Sick Children, Glasgow, showed that 64 per cent. of cases of tuberculosis of the glands of the neck, approximately 80 per cent. of cases of abdominal tuberculosis, and 35 per cent. of cases of bone and joint tuberculosis in children are caused by the bovine bacillus. Another recent investigation is that of Griffith and Summers as regards patients with bone and joint tuberculosis admitted to hospital at Millport, bovine bacilli being found in 33·3 per cent. of the patients examined, while among the children under ten years of age the figure was 56·8 per cent.

The known value of pasteurisation in preventing the consequences of the consumption of infected milk is the principal reason why it is receiving such strong support. There remains the alleged objection that pasteurisation seriously impairs the nutritive qualities of raw milk. This would be a grave objection if it were clearly substantiated. Present knowledge and experience, however, point to the fact that such changes as occur in the composition of milk during pas-

[1] Investigation into Tubercle Bacilli in Milk under Department of Health for Scotland and Empire Marketing Board.

teurisation are small, are negligible where milk is not the sole food, and are otherwise easily remedied in practice by the simple addition of orange juice or, if need be, cod liver oil. Orange or other fresh fruit juice is generally recommended whether the milk be pasteurised or not. It should also be pointed out that pasteurised milk is extensively used for infants and young children without any detectable deterioration in their general condition.

The general position is summed up in the following extract from the *Memorandum on Bovine Tuberculosis in Man*, issued by the Ministry of Health in 1931 : "The problems and procedures of pasteurisation have been reviewed and it has been shown that, subject to careful operation and scientific control, this process ensures a milk which is not only safe for consumption, but also retains its food value practically unimpaired by the heat to which it is subjected."

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MILK is our first food and drink, and in the whole course of life is an almost indispensable constituent of diet, but under the existing conditions of our milk supplies we have been sacrificing the health and the lives of many of our younger fellow-beings for this essential nutrient. It is axiomatic that an abundant supply of a clean and safe milk is a primary requirement of the community. In this country, however, at the present time the consumption is abnormally low, and the advantages to agriculture and the national economy of a larger consumption are apparent. But it is admitted that cleanliness and safety are not qualities which uniformly pertain to our ordinary market milk, and the public cannot be blamed for neglecting this food under present conditions. Other foods may at times accidentally endanger human health, but we have to face the fact that the ordinary raw milk is a constant menace to the public health. Scientific research has provided an almost complete knowledge of the possible dangers and their prevention ; yet there is an unbridged hiatus between this knowledge and actual practice.

In examining the milk problem from the hygienic standpoint attention must be focused on the micro-organisms milk may contain—those derived from the cow, its tissues, excreta and body surfaces and those introduced in the various manipulations to which milk is subjected from the time it leaves the animal till its consumption in the home, including the microbes which human handling may add to it.

Milk is primarily a sterile fluid, but, from the time it flows along the ducts of the udder, is subject to progressive bacterial contamina-

[1] Professor Mackie dealt with the subject more fully in a paper read before the Agriculture Section of the British Association in September, 1933.

tion. It is an excellent growth-medium for putrefactive and intestinal bacteria, and while it can hardly remain uncontaminated, raw milk as sometimes vended may be a veritable bacterial culture. The micro-organisms present may, for the most part, be only those found normally in our own alimentary tract, and it might be argued that if their growth has not advanced to such an extent as to alter grossly the chemical composition of the material, no harm has been done. This may be true for the average healthy adult whose alimentary tract is accustomed, as it were, to a varied bacterial flora and the products of their growth, but we can hardly admit this claim in the case of infants and young children. It has long been recognised that heavily contaminated cow's milk is responsible for a considerable morbidity and even mortality among infants due to gastro-intestinal trouble especially in the warmer season of the year when, as might be expected, the bacterial content of such milk is at a maximum.

In my own bacteriological experience I find the standard of the average retailed milk more than disappointing and particularly when one reviews all that has been attempted to encourage or compel improvement. We have sometimes been asked to console ourselves with the hope that progress is being made, but it is intolerably slow for the idealist in preventive medicine.

Success in producing from the farm a milk which is free from serious contamination may be summed up in scrupulous cleanliness, care and intelligence in dairying methods with the aseptic ideal on the part of all concerned. Too frequently the average dairy worker is ignorant and careless and—worse still—may have dirty habits. It is notorious in fact how unhygienic the conditions of milk production may be. After it has left the farm, milk is still subject to contamination in distribution. Rigorous precautions are also required in the retailing process and, unless the material is kept at low temperatures, bacterial growth multiplies many-fold the initial contamination.

Biological tests and bacteriological standards are essential controls and should be more freely utilised for the check they afford. Especially in the summer season the bacterial content of vended milk may exceed a million living bacteria per cubic centimetre and even reach multiple millions. With proper safeguards it should be quite possible to supply a product conforming to the bacteriological standard of "certified milk," *i.e.*, not exceeding 30,000 bacteria per c.c., which is not a rigorous requirement.

Apart from the ordinary bacterial contamination and its consequences, cow's milk may carry the microbes of certain specific diseases. First and foremost among these is the tubercle bacillus. The facts in regard to this menace are common knowledge now to the scientific agriculturist and to the medical profession, but one finds that the public, though vaguely aware of the possibilities, do not appreciate the position. The facts may be summarised as

follows : at least 40 per cent. of dairy cows are tuberculous ; about 0·2 per cent. of dairy cows have tuberculosis of the udder and in consequence are discharging live tubercle bacilli in their milk; from 2 to 13 per cent. (and an average of 6·7 per cent.) of specimens of raw market milk contain live tubercle bacilli; in England and Wales 2000 deaths (mostly in children) result annually from tuberculosis caused by the type of bacillus derived from cattle; and about 4000 new cases of this form of tuberculosis occur each year. The stated percentage of milk samples infected by the tubercle bacillus probably underestimates the position in the large centres, where the figures may reach 14 per cent. or even higher, and it has been shown that large scale bulking may increase the percentage to 25 or even 50 per cent. It seems almost incredible that, in a community so highly organised in various ways for the saving of human life, a food should be sold, with even a 7 per cent. chance of containing a micro-organism capable of producing a serious, crippling and often fatal disease, and that without forcible warning to the public.

Tuberculosis, though the most important, is only one of the milk-borne infections: from time to time milk supplies may spread enteric fever (typhoid and paratyphoid) and other acute intestinal infections, diphtheria, scarlatina and streptococcal infection of the throat, and quite recently the fact has emerged that undulant fever due to *Bacillus abortus*, the organism of bovine contagious abortion, must be added to this formidable list. Milk-borne enteric fever, diphtheria, and scarlatina are of course due to human contamination, often from healthy carriers of these infections who are handling milk at some stage of its production or distribution. In other cases, the animal may be the source of the infection, as in bovine tuberculosis. Thus septic sore throat may be derived from the milk of cows whose udders are infected by a particular type of streptococcus. Undulant fever (or abortus-fever) should be of particular interest to the agriculturist in view of his close acquaintance with contagious abortion and the serious losses produced by this disease in cattle. In the infected cow the organism localises in the udder and is discharged in its milk often for long periods after abortion. Some years ago abortus-fever was regarded as practically non-existent in this country, but since the condition was first recognised the number of reported cases has been steadily increasing and the majority must be attributed to the use of raw milk. The percentage of samples of retailed raw milk which contain *Bacillus abortus* may seem at first sight alarming ; for example, in an inquiry carried out in my own laboratory, the figure was approximately 35 per cent. It is specially significant that in certain large cities where most of the milk is pasteurised undulant fever has occurred in persons who, unlike their neighbours, have used raw milk (including certified milk) and in some cases while on holiday in another area.

The urgent necessity for eliminating milk-borne tuberculosis

dominates the whole problem of our milk supplies, though the spread of other infections by milk cannot be minimised. The eradication of tuberculosis among cattle is, of course, the fundamental remedy. But immediate complete eradication is impracticable. Much was at one time expected from the operation of the Tuberculosis Order but this measure has made little impression on the root-evil, for eradication involves the removal from dairy herds of all infected animals whether obviously diseased or not. Eradication by practicable means must proceed slowly and, under average conditions of farming, against difficult obstacles.

The production of the designated milks from "tuberculin-tested" cattle has already placed in the hands of the public a limited milk supply that is safe from risk of tuberculous infection, but under present conditions economic factors affecting both producer and consumer must tend to restrict the development of this supply.

In any case, for a considerable time to come tuberculous milk must of necessity be used, and the only immediate remedy is its artificial disinfection. This remedy is no novelty and has been a growing practice of milk distributors for some time past, the main motive being to improve its keeping properties.

The only practicable method of disinfecting milk is by heat, and owing to the deleterious effect of high temperatures on this complex biological product, the temperature and the time of exposure have been reduced to the minimum as in the officially recognised method of pasteurisation at 145°-150° F. (63°-65° C.) and holding at this temperature for 30 minutes.

While such treatment, if carried out by a carefully controlled method, may be regarded as an effective means of disinfecting milk not only as regards the tubercle bacillus but also other milk-borne pathogenic organisms, the margin of safety is not very great. Pasteurisation is a technical process requiring attention to detail, and justifiable doubts have been cast on the uniform efficacy of the method as applied commercially. I have no doubt, from personal knowledge of the results of commercial pasteurisation, that the holding process can function effectively, though further inquiry is needed into the technical faults that may cause inefficiency and into the optimum type of apparatus. In any case the effectiveness of pasteurisation as carried out on a commercial scale must be constantly checked by inspection and by bacteriological tests.

I do not propose to discuss the effects of pasteurisation on the nutritive qualities of milk, particlarly its vitamin content. The only vitamin clearly proved to be affected by pasteurisation is the anti-scorbutic vitamin C, and in any case it is doubtful if the ordinary raw milk uniformly contains sufficient of this and other vitamins for the needs of the growing human organism. The evidence, when critically reviewed, does not provide any valid objection to pasteurised milk either on grounds of qualitative or quantitative nutritive deficiency, though it is obvious that if it constitutes the sole diet of young

subjects a vitamin supplement is required ; but this is an essential even when raw milk is similarly used.

It is sometimes said that the encouragement of pasteurisation may set back the clock of progress towards the fundamental remedy. Perhaps it may, if there is no counteracting motive in favour of the concurrent eradication of bovine tuberculosis ; but I cannot understand those persons who are willing to allow the continuance of milk-borne tuberculosis for many years to come in order that, as they hope, some time in the future a raw tubercle-free milk may be universal.

Under present conditions, and particularly in view of the facts of milk-borne tuberculosis, only two types of milk are justifiably saleable to the public, namely, (1) milk from cattle which react negatively to the tuberculin test, and (2) milk pasteurised *by an effective method under proper control.* Where it is possible to supply the public with these products, as in the urban areas, the sale of the ordinary raw milk should be forbidden. Where such supplies are not immediately practicable the ordinary raw milk should be sold only under an official designation which would make it clear to the public that such milk is not free from possible tuberculous infection, so that the consumer may take domestic steps to sterilise the material he buys. I feel strongly that both our agricultural and public health organisations are doing the people a grave injustice in their tacit sanction of the use of the ordinary milk, and if pasteurisation is not enforced and controlled the only honest alternative is the official designation of this milk in the way I have indicated.

Controlled pasteurisation also eliminates other dangerous infective agents that may sometimes be present in raw milk, and from the hygienic standpoint its influence is comprehensive. This has been clearly borne out by experience in public health practice.

It is said quite truly that pasteurisation does not render a dirty milk clean. It must be recognised that the process does not produce complete sterilisation, and micro-organisms responsible for chemical alterations may survive and later grow in the milk. Pasteurisation does not therefore absolve the producer from his obligations in cleanly dairying methods. A pasteurised milk if improperly distributed and handled may also acquire new and, of course, progressive bacterial contamination. Bacteriological examination of the retailed product supplies a check of the effectiveness of the process and such control is necessary in the public interest to ensure attention to the requirements.

The occurrence of undulant fever due to *Bacillus abortus* raises a further question : this organism may be present in " certified " and " tuberculin-tested " milk, and if the consumers are to be protected from this milk-borne infection, either the producers of these designated milks must clear their herds of contagious abortion (by analogy with the eradication of tuberculosis) or such milks must also be pasteurised.

Recent schemes for the reorganisation of the marketing of milk have directed attention to the future of our milk supplies and the present seems an opportune time for putting into force comprehensive measures—long overdue—providing for the highest possible hygienic standard of dairying and milk distribution, for the progressive eradication of tuberculosis and contagious abortion from dairy herds, for the efficient pasteurisation under official control of all milk derived from infected herds or liable to dangerous contamination from human sources, and, in short, for the production and distribution of milk supplies which can be relied on as safe from the hygienic standpoint.

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It has been conclusively shown that the known imperfections in the dietaries of a great many of the children attending the primary schools in this country can be corrected by supplementing them with a comparatively small amount of milk, a pint a day being often adequate. It is also well known from the results of experiments on rapidly growing animals, such as rats and pigs, that it is of great advantage after the young animal has been weaned to supply milk as one ingredient of the food mixture. In both these cases, by the addition of milk more than by the addition of any other natural foodstuff, can a diet which is not quite up to standard be made efficient.

Since it is so easy to demonstrate the advantage of a milk supplement in the dietaries of man and beast, it might appear as if it should not be very difficult to demonstrate whether pasteurisation of the milk would rob it of any of its nutritive virtues. But this is proving a most difficult problem to solve. Even an experiment such as that which was carried through on a large scale among the school children of Lanarkshire did not give an answer which is unanimously accepted as conclusive and if another such observation has to be undertaken, several variables which were not adequately controlled in that one must be eliminated. Inasmuch as the accomplishment of this will be both costly and time-consuming—owing to the fact that the observations will require to be of much longer duration than in the Lanarkshire experiment—it is meanwhile important that attention should be paid to experiments on laboratory animals. In these, it is ever so much easier to control the tests and to rule out the factors which are uncontrollable when school children are used. Moreover, the tests on animals have the very great advantage that they can be frequently repeated and varied so as to eliminate, one by one as they are revealed, every possible source of inaccuracy. True it may be that the nutritional requirements of man and laboratory animals need not be alike in all details, but it is highly improbable that any serious error

could arise on this account provided the tests are conducted on animals of different species and of varying dietetic habits. It would surely be safe to conclude that, if in no type of animal at any stage of its life pasteurised milk proved itself to be inferior to raw milk, the same would also apply to man.

Professor J. C. Drummond in his contribution to the symposium on "Bread and Milk" recently held under the auspices of the Society of Chemical Industry, said, "Many impartial reviews of the literature dealing with the influence of pasteurisation on milk have led to the conclusion that no satisfactory demonstration of a deleterious action has yet been presented." But this conclusion is not shared by all, and it may be appropriate to refer to one or two of the investigations which at least suggest that pasteurisation may be detrimental. Orr, Crichton and others, using calves, gained the impression that those receiving fresh milk were in better condition than those receiving pasteurised milk. The numbers of animals used were too small to permit of conclusions being drawn with regard to differences in weight increase. The same impressions regarding the better general condition of animals fed on unheated milk were also gained by M'Candlish and Black in similar observations conducted in Ayrshire. Magee and Harvey showed that pasteurisation reduced by almost 6 per cent. the soluble calcium content of the milk, but this may not be of any great significance. More recently Mattick and Golding, of the National Institute for Research in Dairying at Reading, have presented results from which they conclude that effective pasteurisation of milk (at 145° F. for 30 minutes) lowers its nutritive value for rats. This may not be evident in the growth curves of the young, but reveals itself by the poorer general condition of the animals and by the fact that they propagate less satisfactorily than those kept on raw milk. But the difficulties inherent in such investigations are clearly revealed by the results obtained by Drummond and his associates at University College, London. These workers repeated the Reading experiments, using the same milk and the same biscuits to feed their animals, and their conclusion is that it was not possible to "detect any evidence that pasteurisation adversely affects the nutritional value of milk." This conclusion was not altered in the light of later experiments in which the diets were supplemented by the addition of vitamin B.

At the same symposium the results of similar experiments on mice were presented by Wilson and Cowell. These showed that the mice did not thrive on a diet of raw milk and biscuit alone, or on this *plus* either a mineral mixture of iron, copper and manganese, or vitamin B, but did so when both of these supplements were added. In none of the experiments, however, neither those in which a somewhat deficient diet was used nor those in which the diet was apparently adequate, was pasteurised milk found to be inferior to raw milk with respect to survival and the breeding

powers of the mice. But the young of mice fed from birth on the raw milk diet put on weight very rapidly, and "appeared to be more lively and in better general condition than those brought up by does on pasteurised milk." The authors do not consider that they have performed a sufficient number of experiments to justify general conclusions being drawn, but the preliminary results are at least suggestive.

It must again be emphasised that observations on the nutrition of laboratory animals are often misleading when the results are directly applied to man. The diets in the foregoing experiments are entirely different from those used by man, and they are chosen in the laboratory experiments with the object of showing whether pasteurisation under *any* conditions can affect the nutritive qualities of milk. That an excessive milk diet is in itself not entirely normal is shown by the fact that the cæcum of the animals fed on it in many of Drummond's experiments was found to be unusually enlarged.

The chief lesson to be learned from these experiments on laboratory animals, and particularly from the more recent ones, is that it would at present be practically impossible to gain an answer to the main question: raw *v.* pasteurised milk, by observations on man. When we take into consideration the fraction of the total span of life during which such observations could be conducted on children with that possible when laboratory animals are used, it is clear that it would be impossible, even if growth and general well-being were alike in the pasteurised and raw milk groups, to make certain that pasteurisation did not deprive the milk of some property which would result in the later years of life in some nutritional defect. And in this connection, it may not be out of place to add that it is quite possible that comparatively slight deficiencies in the dietaries of the young may be responsible for the occurrence of some of the so-called chronic diseases of adult life. For the present, in my judgment, it would at least be advisable to have the guidance of further experiments on laboratory animals before undertaking another human experiment. It may be that administrators, on account of its great economic importance, are anxious for an answer to the question whether pasteurisation deteriorates the nutritive qualities of milk, but scientific research cannot be hurried beyond a certain pace, which in this particular instance is determined by the rate of growth and the powers of propagation of the smallest and fastest living animal we can use as test objects. In so far as available evidence goes, the scientific verdict must be that risks to the health of human beings *may* be incurred when the dietary of the child is composed in large part of pasteurised milk.

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In recent years, the value of raw milk as compared with pasteurised milk is a subject which has continuously engaged the interest both of the agriculturist and the hygienist. The question is highly controversial and, unfortunately, conclusive reliable data are not yet available. In such scientific arguments we are accustomed to pay too much attention to the "seed" and too little to the "soil."

Let us first consider the result of pasteurisation on milk. It is acknowledged that pasteurisation, by the holder process, carried out by an efficient plant, destroys the pathogenic organisms causing bovine tuberculosis, scarlet fever, diphtheria, typhoid and paratyphoid fevers, dysentery, and the *Brucella abortus*—which is the cause of undulant fever in man and is of much more frequent occurrence than is generally supposed to be the case. All these are milk-borne diseases, and it has been definitely demonstrated that pasteurisation is, in most instances, the only efficacious preventive measure that can be adopted.

But it cannot be denied that the artificial heating of milk has a definite action on several of its constituents. It must, however, be remembered that except in pregnancy, lactation and general sickness, milk as a food for the adult must always be of secondary importance. The process of pasteurisation, which consists in heating the milk to a temperature of 145° F. for at least half an hour and then immediately cooling it to not more than 55° F., naturally produces physico-chemical changes; calcium and phosphorus are changed into a form which adversely influences their availability; the iodine content of the milk is diminished; certain vitamins, such as C and D, are affected. For children and adults it would appear that pasteurised milk is as valuable a component of the diet as raw milk, because the bulk of the nutritive requirements in their case is satisfied from sources other than milk. On the other hand, milk is the staple food of infants and it is generally accepted that, if children are fed solely on pasteurised milk, their nutritive requirements must be augmented by the addition of orange juice or cod liver oil.

From the bacteriological viewpoint, therefore, the advantages of pasteurisation are obvious. Not only are the ordinary disease-producing organisms destroyed, but the keeping qualities of the milk are improved.

Now let us turn to raw milk. Over 10 per cent. of random samples of raw milk contain virulent tubercle bacilli, and, in addition, the milk, being an excellent nutrient medium for the growth o bacteria, may harbour the pathogenic organisms causing diphtheria, scarlet fever, and the like. Indubitably, pasteurised milk is a safer food than ordinary raw milk. Within the last fifteen years, out-

breaks of typhoid fever, gastro-enteritis and streptococcal sore-throat have, in this area, been traced to infected milk supplies.

Tubercle-free milk occupies an entirely different position. Grade A (T.T.) milk is supplied by four producers to the Municipal Hospitals in the City of Aberdeen and it has been the policy of the Local Authority to encourage the production of this milk. Although it is highly nutritive and is free from tubercle bacilli, it might easily carry the milk-borne diseases already mentioned—excepting tuberculosis—although no such experience has so far occurred here.

The present position is, in my opinion, that the process of pasteurisation interferes to a slight degree with the dietetic value of milk, but pasteurisation is the means of preventing so many dangers, from the viewpoint of health, that the process must be extended. There is no definite statistical evidence that the continued use of pasteurised milk is the only factor in the causation of rickets and dental caries in the human being.

Experience leads one to the conclusion that compulsory pasteurisation is essential in large centres of population. In London 95 per cent. of the milk is treated by this process, and within the last fifteen years no case of undulant fever has been recorded. In rural areas and in small burghs efficient pasteurisation will be economically impracticable for many years to come, and in purely rural areas it will never be practicable.

No doubt the ideal would be tubercle- and abortus-free cows, free from mastitis and milked by milkers who were not carriers of any communicable disease; but, as such an ideal is unattainable, we must fall back on clean pasteurised milk as the only safe food of exceptional value for the young.

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Before setting out to discuss the question of pasteurisation of milk, let me make my position perfectly clear by putting the following question to myself. "Do you advocate the pasteurisation of the milk of cows that have been tested and declared free from tuberculosis, and from byres where strict cleanliness is practised?" My answer is "Emphatically, no."

But we have not arrived at that highly desirable state of affairs. That being so, we must approach the problem of pasteurisation from a judicial standpoint. It is wrong and unfair to condemn pasteurised milk in an offhand way because vitamin C is injuriously affected. There are other things to be considered. It is matter for regret that the process of pasteurisation, as frequently operated, leaves itself open to criticism. For instance, all methods of pasteurisation are not uniform. Take the "Flash Process" as an example of an unreliable and unscientific system. My own experience of an

installation of that type at Leith was most disturbing. The milk revealed a greater number of micro-organisms per c.c. after than before treatment, because the all too short application of heat had actually encouraged the multiplication of bacteria in the milk. A critic who took that example as an argument against pasteurisation would be unjust, because Pasteur, the originator of the process, never advised such a slap-dash method as the "Flash Process." Pasteur's discovery was prompted by an urgent demand from the French wine producers to discover a scheme that would save the grape juices from destruction by fermentation.

But for the discovery of pasteurisation and its power for good, the peasantry and wine trade of France would have been ruined. Criticism is occasionally excited when the more modern apparatus, designed to hold bulked milk in contact with the required heat for half an hour, reveals weaknesses. When some of the milk under treatment escapes the heat, or is not sufficiently heated, the bacteriologist now and again comes forward with the disheartening announcement that he has isolated tubercle bacilli from the milk that was supposed to have been pasteurised. The bacteriologist may heap further coals of fire on the head of the producer by declaring that the tubercle bacilli were alive and had in fact infected guinea-pigs. When, in addition, we are told that the numbers of *Coli bacilli* present exceeded the limits permitted, our faith in the pasteurisation of milk on a commercial scale is apt to receive a rude shock.

The occasional discovery of tubercle bacilli in commercially-heated (I cannot call it pasteurised) milk is a weakness that must be corrected and guarded against by the producer, if he wants to stand on a sound platform.

Another criticism advanced against pasteurisation is that the heat employed kills the "policemen" of the milk, to wit, the *lactic acid bacilli*. When the souring of milk is rendered impossible by the destruction of those bacilli, the consumer may drink a liquid that is being peptonised by micro-organisms capable of producing gastro-intestinal manifestations. The lesson to be learned from that knowledge is that only freshly prepared pasteurised milk should be used. Pasteurised milk that has been standing in a bottle for a few days (in a warm kitchen perhaps) may provide a really harmful food.

Having referred to the weakness of the process, let me turn to one or two of its good features. It is very appropriate to this discussion that the *American Journal of Public Health* within recent weeks published the results of an inquiry bearing on "Milk-borne Outbreaks of Infectious Disease in Massachusetts, between the Years 1930-32." The areas covered by the inquiry carried a population of 5,000,000 persons. In Massachusetts 85 per cent. of the milk supplied is pasteurised. The replies sent in showed that there had been 5 outbreaks of septic throat, 3 of typhoid fever, 1 of scarlet fever and none of diphtheria. The sore throat out-

breaks attacked 178, 17, 17, 10 and 18 persons. There were 3 deaths, and in every one of the outbreaks infection was traced to the consumption of raw (non-pasteurised) milk. Of the 3 typhoid fever outbreaks none exceeded 18 cases, and all were traced to raw milk. There had been 9 cases of scarlet fever traced to the consumption of milk that had been pasteurised, but the infection of the milk took place during bottling and capping operations. The infecting agent was an assistant who had been suffering from a mild (undetected) form of scarlet fever.

Since milk pasteurisation became more or less a universal system, milk-borne outbreaks of infectious disease in America have disappeared. Even its most obstinate opponent must admit the value of pasteurisation from that preventive standpoint. When we come to deal with what might be termed the inherent defect of pasteurised milk (apart from the destruction of *lactic acid bacilli*), we are forced to admit that the heat required does injure the vitamin C content. But it is at this stage of the discussion that the man with the open mind will be expected to temper his criticism with justice.

If every man, woman and child in this country had to subsist for prolonged periods on pasteurised milk their health would undoubtedly be prejudiced, because their supplies of vitamin C would be unduly reduced. But no sane person can picture such a condition of existence. Every one nowadays, during some period of each day or week, consumes fresh vegetables, fruits or other articles of diet containing vitamin C. Children who are expected to drink raw milk at school, whether they want it or not, do not rely on a few ounces of that liquid for their vitamin C supplies. Yet one would almost imagine that they do when the case for or against pasteurised milk is debated.

The prolonged experiment conducted in the schools of the principal cities of Scotland and in Belfast clearly demonstrated that those who drank pasteurised milk emerged at the end of six months in as good physical condition as the others who had consumed raw untreated milk. The experiment indicated that vitamin C as well as other accessory food factors were consumed outside of school hours. If the truth were admitted, it would be confessed that we have heard and read far too much about elusive and somewhat illusory vitamins, and too little about properly balanced and mixed diets. Rats kept in cages and fed on a diet deficient in one or other of the accessory food factors were bound to suffer in health. But human beings who can move about to fend for themselves are in a totally different category. When Cook undertook his round-the-world voyages of discovery, his crews suffered from scurvy because their supplies of fresh foods ran short. They had no option but to eat the salt beef and preserved foods that were on board. We rarely hear about scurvy now because we mix our diet. Instinct teaches us to do so.

milk than when raw milk formed the bulk of the diet. Pasteurisation also caused appreciable losses of the iodine present in the milk. Magee and Harvey also measured the relative concentration of soluble calcium salts by dialysis.[1] They found there was a loss of about 23 per cent. of diffusible calcium in pasteurised milk when compared with the diffusible calcium in non-pasteurised milk. The loss of soluble calcium on pasteurisation is suggested by Milroy to be due to the formation of colloidal and, therefore, of unassimilable tricalcium phosphate. A review of all the published work on the chemistry of pasteurised milk would occupy too much space, and, in any case, would be too technical, and therefore inappropriate in a short article written for the general public.

Summarising the chemical results in a sentence, we can say that the *advantage* of the destruction of tubercle bacilli, if present, brought about by thorough pasteurisation, is accompanied by changes in the chemical composition of the milk which are probably disadvantageous. Changes take place in the calcium and phosphate of the milk which probably decrease the assimilability of the bone-forming salts. Want of space prevents me from quoting the results of experiments on young pigs and on calves—experiments conducted to test whether the loss is material or not. Whether, in the case of young children, this loss is appreciable or not, must be determined by a rigorous and carefully planned experiment.

A large-scale experiment on 20,000 children was conducted in Lanarkshire in 1930, a full account of which is given in a pamphlet published in that year.[2] The conclusion reached by the authors was that "In so far as the conditions of this investigation are concerned, the effects of raw and pasteurised milk on growth in weight and height are, so far as we can judge, equal."

The experiment and the conclusion reached have, however, been criticised by well-known statisticians, namely, (1) R. A. Fisher and S. Bartlett,[3] and (2) "Student."[4] Professor R. A. Fisher and his colleague pointed out that in each group of children, as subdivided for age and sex, the increases in height and weight were greater, apart from a few unimportant exceptions, with raw than with pasteurised milk. If these groups can be taken as supplying independent evidence the difference in favour of raw milk was significant. Moreover, this difference represented a substantial fraction of the total increase in growth produced by milk feeding. Combining the data of all ages they found that for weight of boys, pasteurised milk had only 66 per cent. of the value of raw milk, and for weight

[1] Magee and Harvey. *Biochemical Journal*, vol. xx., pp. 873-83.

[2] "Milk Consumption and the Growth of School Children." Report on an Investigation in Lanarkshire Schools, by Gerald Leighton and Peter L. M'Kinley. H.M. Stationery Office, price 3d.

[3] "Pasteurised and Raw Milk." *Nature*, 18th April 1931.

[4] "The Lanarkshire Experiment," by "Student." *Biometrika*, vol. xxiii., Dec. 1931, pp. 398-406.

of girls, 91 per cent. Considering increase in height, they found that pasteurised milk had only 50 per cent. of the value of raw milk for boys, the corresponding figure for girls being 70 per cent. Boys, however, are more active than girls.

It is pointed out by "Student" that the data are not comparable, that the children receiving pasteurised milk were in different schools from those fed on raw milk, and that the district was a heterogeneous district both racially and socially. Proper precautions were not taken to ensure that all the children were on the same footing except as to the nature of milk feeding, the effects of which were to be tested. It did not occur to the parliamentary authorities, or it may have been found difficult for them, to secure that pairs of brothers and pairs of sisters *in the same school* should be fed, the one with pasteurised milk and the other with whole fresh milk —age, stature and weight being recorded in order that the statistician should be in a position properly to compare groups of brothers and groups of sisters fed according to the scheme.

In view of the importance of the problem, the Department of Health for Scotland placed the whole records of the experiment at the disposal of the Galton Laboratory for National Eugenics at University College, London. The results of the statistical analysis of the records carried out in this well-known laboratory will probably appear at an early date in the *Annals of Eugenics*, a journal edited and published by Professor Karl Pearson, the founder and editor of *Biometrika*. who has just retired from the Chair endowed by Sir Francis Galton, and who is the world's pioneer in the mathematical treatment of biological data and, in particular, in the scientific study of racial problems.

We shall doubtless know from this high authority and his co-worker, Dr E. M. Elderton, what definite conclusions can be stated from the nature of the data. There may be inconclusions which could have been avoided, had the scheme had the benefit of the advice of leading statisticians prior to the starting of this experiment.

All workers on this difficult problem, biochemists, bacteriologists, nutrition experts and statisticians, are making an honest effort to find the true solution. From the chemical standpoint, it can be definitely stated that milk after it has been pasteurised is not the same as the original article. Statistically there are indications that the effect of pasteurised milk on young children is not the same as the effect of raw milk, but no *definite* conclusion has yet been reached.

The *raison d'être* of the process of pasteurisation of commercial milk (bulked or otherwise) is the protection it gives from certain infections. The activities of local authorities, associated as they are, and should be, by the State, in the direction of the elimination of all sources of disease, are bound to have a beneficial effect on the quality of commercial milk. Pasteurisation is only a temporary

measure to be abandoned when dairy farming has reached the state envisaged by the public health authorities. The sooner that day comes the better will be the health both of the old and the young of the entire community.

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SINCE an adequate discussion of this subject would occupy far more space than is here permitted, I propose to restrict myself to a consideration of the main issues only, forming as dispassionate a judgment as possible on the scientific evidence available. I shall still further restrict myself to the public health aspect of the problem. Once a definitive conclusion is reached as to the relative merits of raw and pasteurised milk in the feeding of the human population, it will be time enough to consider the various adjustments that will be demanded of the producing and distributing sides of the milk industry if full effect is to be given to the knowledge obtained. At the outset I want to make it quite clear that in using the term pasteurisation, I imply the exposure of milk in properly constructed and efficiently operated plant to a temperature of 145-150° F. for 30 minutes with subsequent cooling to a temperature of 55° F. or below. This definition excludes a considerable proportion of so-called pasteurised milk at present on the market. The discussion falls naturally under two headings.

(1) *The Nutritive Value of Cow's Milk.*—Cow's milk differs in a number of important respects from human milk, and is not an ideal food for infants. Besides having to be diluted with water and fortified with additional sugar, it has frequently also to be supplemented with orange juice, cod-liver oil and iron, or similar products, to ensure protection against scurvy, rickets and anæmia. The effect of low-temperature pasteurisation appears to be to render the caseinogen more digestible, to reduce the amount of soluble calcium, and possibly phosphorus, to a slight extent—something of the order of 5 per cent.—and to destroy a variable amount of the vitamin C. The first of these changes is presumably beneficial; the reduction in soluble calcium and phosphorus is not likely to be serious, because there is about four times as much of these elements present in cow's milk as in human milk; and the reduction in the vitamin C can easily be made good by citrous juice or potato extract. Whether more subtle changes occur it is impossible to tell by chemical methods, and resort must therefore be made to animal experimentation. Careful analysis of the work carried out on different animals fails to show any significant diminution in the nutritive properties of milk on pasteurisation which cannot readily be made good by the addition of simple substances to the diet. There are, however, suggestions, at present unconfirmed, that in very early life the increase in weight, the

general vitality of the animal, and the development of the teeth may be slightly superior on raw milk. The only way to ascertain whether these differences really exist, and whether, if they exist, they are of importance in human development, is to make very carefully controlled observations on infants under 1 year of age. It is difficult, however, to believe that they can be of any great importance. An average of nearly 90 per cent. of the milk in cities of 10,000 or over in the United States of America is pasteurised, and no disturbances of infant development appear to be manifest. A recent inquiry, moreover, carried out in the United States on over 3700 children of 10 months to 6 years of age showed that children who had received nothing but heated milk were in fact slightly, though not significantly, both heavier and taller than those which had received raw milk for more than half their lives.

(2) *Diseases Caused by Cow's Milk.*—Here we have better documented evidence. Milk must always be a potentially dangerous food when consumed in the raw state, partly because of the frequency with which it is contaminated with pathogenic organisms, and partly because it serves as an excellent nutrient medium for the growth of many types of bacteria. The milk may be infected through disease of the cow's udder with bovine tubercle bacilli, *Br. abortus*, hæmolytic streptococci, and occasionally with other organisms dangerous for human beings, while during and after its collection it may be infected through human agencies with diphtheria bacilli, with the hæmolytic streptococci of scarlet fever and septic sore throat, with typhoid and paratyphoid bacilli, and with related organisms of the dysentery and food-poisoning groups. As the result of a recent investigation I have found that during the 20-year period 1912-1931 there were at least 81 outbreaks of milk-borne disease in Great Britain, affecting about 10,000 persons. During the same time about 100,000 persons contracted tuberculosis of bovine origin through the consumption of milk, and an indefinite number suffered from undulant fever due to infection with *Br. abortus*. These figures are for various reasons incomplete, and afford but a conservative estimate of the total amount of milk-borne disease. They are, nevertheless, sufficiently formidable to demand serious attention. As I have on more than one occasion pointed out, clean milk and safe milk are not synonymous terms. Numerous outbreaks of disease, both in this country and the United States, have resulted from the consumption of milk produced under very hygienic conditions. Cleanliness of production affords no guarantee, therefore, of the safety of the milk. Since all raw milk is potentially dangerous for human beings, the only logical procedure in the safeguarding of the public health is to expose the milk to adequate heat treatment. Pasteurisation, properly carried out, destroys all the organisms that have been mentioned, and, provided due care is taken to avoid contamination of the milk after processing, it eliminates the risk of milk-borne disease.

Summing up, my opinion is that for the general population all liquid milk and cream should be adequately pasteurised. For the infant population I am likewise strongly in favour of pasteurisation, provided the usual supplements, desirable even with raw milk, are made. While admitting that our knowledge of the relative nutritive values of raw and pasteurised milk is still incomplete, I consider that the known advantages of pasteurisation in the prevention of disease, deformity and death so manifestly outweigh any minor problematical diminution resulting in the food content of the milk that we have no other course in the interests of the public health but to recommend it. For those who are unable to agree with this conclusion a supply of raw milk should be made available, produced by animals free both from tuberculosis and contagious abortion. If pasteurisation is to be generally adopted, steps must be taken to ensure that the milk is produced under cleanly conditions and that the processing is carried out efficiently. Dirty milk is unsuited for human consumption, whether pasteurised or not. For this reason I should strongly advocate a pre-pasteurisation standard of cleanliness, and a special bonus for milk coming from disease-free herds. Confidence in the safety of our milk supply, which alone can be obtained by pasteurisation, will, I believe, result in an increased consumption of milk which in its turn will react favourably on the health and wealth of the community.

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THE prosperity of the milk industry depends very largely on the sale of liquid milk, and no decision will be of greater importance in this connection than that with regard to the proposal for the compulsory pasteurisation of all milk (other than that from tuberculin-tested herds) destined for liquid consumption. Apart from the relation of pasteurisation to the reduction of milk-borne disease and to the nutritive value of milk—subjects which are primarily the concern of the medical profession—certain other factors must be taken into account in deciding whether a policy of compulsory pasteurisation for city milk supplies is justifiable. Such factors include the effect of compulsory pasteurisation on producers' and consumers' prices; its reaction on the producer-retailer and small dairyman; and its influence on clean milk production and disease eradication. I have recently made a careful inquiry into these aspects of compulsory pasteurisation, and, on the basis of the evidence so far collected,[1] the following tentative conclusions may be noted:—

Pasteurisation has been widely adopted in many English cities

[1] Detailed evidence on the points at issue will be found in a paper read at the annual meeting of the British Association for the Advancement of Science, 1933. Copies of this paper may be obtained from the writer.

during the last twenty years, and in some cities (*e.g.* London and Glasgow) as much as 80 per cent of the milk supply is already pasteurised.[1] In spite of this fact no unfavourable price reactions can be attributed to the widespread adoption of the process. As regards the consumer's price, the index of retail milk prices ran parallel to the general index of retail prices of other foods until 1927, although the percentage of milk pasteurised rose, in London, from 30 per cent in 1913 to over 80 per cent in 1927. As regards producers' prices, it is found that, when these are expressed as percentages of the retail price—the only reliable means of studying comparative changes in a time of fluctuating prices—they remain practically constant at 60 per cent. In spite of the rapid growth of pasteurisation, therefore, the producer's share in the retail price has in the past[2] remained reasonably constant. In this connection it may be stated that fluctuations in the producers' prices due to the varying proportions of milk paid for at manufacturing rates are dependent mainly on supply and demand, and bear no relation to pasteurisation. Moreover, information obtained from cities in the United States and Canada, in which compulsory pasteurisation is in force, bears out the contention that it has little, if any, effect on producers' or consumers' prices. There is in fact evidence that, following the adoption of compulsory pasteurisation, liquid milk sales have risen, with a corresponding increase in the proportion of milk for which the liquid price is paid—a fact which has materially benefited the producer.

With regard to producer-retailers, it is found that, in large cities, they supply an average of about 10 per cent of the milk consumed. This estimate is, however, based on figures for 1932, when falling prices had forced many farmers to retail their milk in order to secure a maximum return for their produce. Such a growth in the number of casual producer-retailers is detrimental to the general body of producers, since their competition results in lowered retail prices, and therefore lowered producers' prices, without solving the paramount problem of raising either the consumption or the manufacturing price of milk. The elimination of this type of producer-retailer, which would undoubtedly be one result of compulsory pasteurisation, would therefore be advantageous to the ordinary producer. As regards the long-established producer-retailer, it appears that the natural outlet for him is the sale of high-grade tuberculin-tested milk. Thus he is in close proximity to his market, he is in personal contact with his customers and he can offset his higher production costs by eliminating the middleman. Compulsory pasteurisation

[1] Although the growth in pasteurisation has in some centres been rapid, it should be clearly understood that, when adopted *voluntarily*, the processing may not necessarily be carried out with proper safeguards. Under *compulsory* pasteurisation, however, the adoption of efficient methods of processing could be made obligatory.

[2] There is reason to believe that, with the advent of the new milk marketing schemes, the tendency in future will be for the producers' organisations to secure a dominant position in controlling milk prices.

might well provide him with a relatively stable—if not an exclusive—market for his milk.

In considering the position of the small dealer, it appears that compulsory pasteurisation will, in all probability, make it extremely difficult for him to continue in business. It is, however, doubtful whether even at present he is an economic unit in the larger centres of population, and there is some evidence to show that he can be, and is, used as a screen for keeping up the retail price of milk—to the manifest advantage of the large dealer. Nevertheless experience in the United States and Canada indicates that he may be able to survive compulsory pasteurisation, either by installing small-scale plant, or by co-operating with other dealers in the erection of larger plant, or by purchasing supplies of pasteurised milk from large dealers. The latter practice is already relatively common in this country.

The argument that pasteurisation will discourage clean milk production is based on the erroneous impression that pasteurisation will mask the inherent defects of milk produced under dirty conditions. Recent work indicates that the methods of production exert a great influence on the suitability of milk for pasteurisation, since dirty methods lead to serious difficulties in the subsequent heat treatment. Moreover, judging from reports received from American cities in which compulsory pasteurisation has been in force for some years, it appears that the hygienic methods of handling milk at the farm have shown a definite improvement since processing became obligatory. In any event, any retrograde tendency could be prevented by the inclusion of a suitable pre-pasteurisation bacterial standard in any legislative measure giving effect to compulsory pasteurisation.

Finally, in answer to the criticism that compulsory pasteurisation will discourage disease eradication, it might be asked, "What is in fact now being done in Great Britain to eradicate bovine disease ?" Careful inquiries in a number of large cities show that, although the Milk (Special Designations) Order has been in force for ten years, only 2 per cent of the milk supply is derived from tuberculin-tested herds. In comparison the American figures for over 400 cities, supplying a population of 40,000,000, in which compulsory pasteurisation is in force, show that nearly 90 per cent of the milk, irrespective of whether it is to be pasteurised or not, is derived from tuberculin-tested cows. It is impossible in the light of these figures to accept the contention that compulsory pasteurisation is antagonistic to disease eradication. The real fact appears to be that the extent of disease eradication is largely, if not entirely, dependent on the measure of active assistance which is provided by the State.

If the implications of the above facts are accepted—and there seems to be no reason to doubt their validity—it must be concluded that compulsory pasteurisation, by providing the consumer with a

milk supply of guaranteed safety (thus stimulating the consumption of liquid milk), by eliminating the casual producer-retailer as a competitive element in the milk market, and by putting the uneconomic small dealer out of business, would be of material benefit to both the producer and consumer of milk.

SOME CONSEQUENCES OF TECHNICAL PROGRESS IN AGRICULTURE[1]

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A good deal of recent agricultural history may be summed up by saying that it has been becoming easier and easier to produce, and more and more difficult to sell. Just how far the difficulty of securing a remunerative price is a result of the farmer's own success in increasing his production is a question upon which opinions differ. It is not the purpose of this article to argue this aspect of the matter. That purpose is merely to point out, firstly, that the rate of improvement in agricultural technique is getting progressively faster, and secondly, that the rate of increase of the world's population is getting progressively slower; and that these two broad facts, taken together, seem likely to have profound effects upon the future of the agricultural industry.

Let us illustrate the first point by reference to the history of wheat production. Starting in mediæval times, the yield of wheat in Britain was probably of the order of 12 or 14 bushels per acre, and its production probably involved about 12 man-days of labour. The output per man-day was thus a little over 1 bushel. From that time onwards we may distinguish three main eras in the technique of production.

In the first of these, which lasted till the end of the eighteenth century, all the operations of tillage, harvesting and threshing were performed either by man labour and the use of simple tools, or else by horse or other animal labour with the help of relatively simple implements like the single-furrow plough. Also the fertility of the soil was maintained solely by means of the so-called "natural" manures like dung, lime and marl. Towards the end of this period there was severe pressure on the available supply of land suitable for wheat and, especially during the Napoleonic wars, there was a great effort to intensify production on the available area. At the end of the period, after enclosure, with the help of "restorative" crops like clover, and with the allocation of a good deal of land to stock—in order to make dung—the yield was raised to something like 24 bushels per acre. The labour of production remaining

[1] Substance of a Paper read before the Economic Section, British Association, at the Leicester Meeting, 1933.

about the same, we may say that the output per man-day, as well as the output per acre, had been approximately doubled.

In the second era, which lasted throughout the nineteenth century and until about the end of the Great War, there were notable advances of two kinds. Firstly there was considerable progress in mechanisation. Meikle's thresher, invented in 1784, had largely replaced the flail by 1840. In the 'twenties came Bell's reaper; in the 'fifties M'Cormack's more perfect machine; in the 'seventies the binder. These machines reduced the direct human labour of wheat production by about 50 per cent.—say from 12 to 6 man-days per acre. Concurrently the yield per acre was raised, largely through the use of artificial manures, from 24 to about 30 bushels. Before the Great War progress was being held up, so far as this country was concerned, by the scarcity of nitrogen manures, to which difficulty Sir William Crookes devoted his Presidential Address to the British Association in 1898. In 1913 it took a sack of wheat to pay for a hundred-weight of sulphate of ammonia. Still, the gross output per man-day had been raised from 1 bushel in 1400, and 2 bushels in 1800, to about 5 bushels in 1900. A further point of importance is that, whereas in 1800 increased yield per acre was the main objective, the aim in 1900 had been shifted to that of a larger output per man—the available reserves of wheat land having in the meantime been vastly increased by the opening up of the prairie countries.

The third period, which is only commencing so far as this country is concerned, is witnessing the introduction of three new mechanical inventions—the tractor (with its appropriate large implements of tillage), the combine harvester and the grain drier. The first reduces the direct man labour of tillage by some 75 per cent.—that is a man with an average tractor can plough, or harrow or cultivate about four acres for every one that can be ploughed or harrowed or cultivated with a pair of horses. The "combine" reduces the number of harvest operations from four—viz., cutting, stooking, stacking and threshing—to one. The drying plant—which is a necessary complement to the combine in our climate—largely eliminates the largest risk of the enterprise, that of damage by bad harvest weather. It is understating the effect of these innovations if we say that they result in again cutting the labour cost in half. In this country a 30-bushel crop can be produced with about 2½ days' work, while the 18-bushel crop of parts of the American Wheat Belt costs about 1½ man-days. In either case the output per man-day would be approximately 12 bushels. Simultaneously Sir William Crookes's problem has been solved by the invention of the various processes for the fixation of atmospheric nitrogen, so that there is now no reason to fear the rapid exhaustion of the world's wheat soils. And simultaneously again, the available reserves of wheat land have been immensely increased by the work of plant breeders. In Canada their efforts have

resulted in the northward extension of the limit of wheat cultivation by hundreds of miles. In Australia the production of drought-resistant varieties has opened up another great tract to wheat culture. In this country the next step of progress will doubtless be the breeding of new varieties which will respond to the heavier applications of nitrogen which would be, but for the risk of producing an over-luxuriant crop, highly profitable.

One consequence of these developments is that wheat has become very abundant and cheap; and it is an old economic paradox that the cheaper bread becomes, the less of it people eat —*i.e.*, when the consumer's real income is high he tends to substitute other and more expensive foods—semi-luxury articles—for the plainer and less attractive forms. From the consumer's point of view wheaten bread was at one time a luxury; it then came to be regarded as "the staff of life"; and it is now, among the more prosperous classes of the community, being relegated to a comparatively minor place in the dietary.

Professor Ashby has recently made a wide and general survey of the changes in the efficiency of agricultural production, and his figures show that the same tendency can be traced in relation to most commodities. A few of his conclusions referring to the dairy industry may be quoted. The average milk yield of British dairy cows increased between 1885 and 1931 by about 40 per cent., and in the six-year period. 1925-31, by 12 per cent. In Denmark the output of butter per cow, which was already high in 1914, has since increased by 26 per cent. In New Zealand between 1909 and 1929 the output of butter, per man employed in the dairy industry, rose by 59 per cent.

The same author has collected estimates for the industry as a whole. He finds, for instance, that in the United States during the present century the physical output per acre has risen by 25 per cent. and the output per man engaged in agriculture by 34 per cent.—the greater part of the increase, in both cases, having occurred since 1921. As regards Britain he concludes that efficiency, as measured by the physical output per man engaged in agriculture, has risen by about 1 per cent. per annum since 1870, and that, despite the recent depression, this rate of progress has been maintained to the present date.

If our review could be extended to include tropical agriculture it seems likely that, so far as production is conducted upon a commercial scale, even more striking figures would be obtained. The introduction of new varieties of sugar-cane, the new method of vegetative propagation of rubber, the use of artificial manures for tea and for rice have so improved the efficiency of the various industries that real and heavy over-production has resulted, and international restriction schemes have been found necessary.

The broad facts that must be realised are that the rate of increase in output, per man employed in agriculture, is already

greater than the rate of increase of population; that the rate of progress in agricultural production is tending to become faster, while the rate of increase of population is likely to become progressively slower; and, finally, that the possibility of any real pressure upon the available area of agricultural land is so remote that it may be left out of account.

It is clear, therefore, that, apart from the possibilities discussed below, we should have to reconcile ourselves to a decline not only in the *proportion* of agriculturists in the world's population, but also to a decline in their *total number*. The decline in the proportion of agriculturists has been a marked feature of the population figures of the more progressive countries for many years. For example, in the United States the proportion has declined from 44 per cent. to 21 per cent. since 1850. In Canada the proportion was 48 per cent. in 1881, and had fallen to 33 per cent. in 1921. There has, of course, occurred a decline in the actual numbers of agriculturists in certain of the old countries of Europe. But this has been mainly due to the migration of farmers and farm workers to America and Australasia, and this outlet is rapidly disappearing. An actual decline in the numbers of agriculturists in the world as a whole would be a new phenomenon.

Among the consequences of technical progress in agriculture it might seem logical to expect a general shortening of the hours of labour. If a given operation can be performed in 8 hours instead of 12, a man might work 8 hours instead of 12. The amount of leisure enjoyed by agriculturists is substantially less than that enjoyed by workers in other industries and, so far as wage-earners are concerned, it is open to any country to secure the benefits of progress in the form of increased leisure for the workers. The difficulty is that in all countries a large proportion of the workers are not wage-earners, but peasants or family farmers; indeed, taking the world as a whole, something over 80 per cent. of the agricultural output is produced by the latter class; and there is no means of enforcing a labour code in the case where a man employs only himself. It is also worth noting that the peasant tends to react in a peculiar manner to changes in the value of his products If these become cheap—owing to over-supply, for example—he tends to work longer hours in order that he may produce more, and he tries to live more sparingly in order that, by having more to sell at the lower price, he may still obtain the funds to meet his cash commitments. The competition of the worker who has "no hours" is bound to remain an obstacle to the application of the principle of spreading out a diminishing amount of work among a constant number of workers.

From the point of view of those who would regret a decline in the number of rural workers, a more hopeful aspect of the matter is the probability that demand will shift from the cheaper "necessaries," which involve little labour of production, to luxury or

semi-luxury commodities requiring more labour. To return to the case of wheat, the technique of production has been so rapidly improved that there is an unmanageable surplus, and the price has fallen below the cost of production. But it is easy to convert the unwanted wheat into another commodity such as eggs. It takes approximately half a pound of cereal food to produce an egg, and further labour is employed in the process. It is true that in the process something like 90 per cent. of the calorific value of the original cereal is lost; but, if the consumer is prepared to pay less than a halfpenny for the cereal and perhaps more than a penny for the egg, the conversion may still be profitable to the poultry-farmer.

The change-over of demand to agricultural products that were formerly regarded as luxuries is already very marked. Our home output of eggs has more than doubled in twenty years. The demand for the choicer vegetables, such as tomatoes and green peas, is expanding very rapidly; so also is that for fruit and even for flowers. It would seem that in any scheme of planning for the future the probable continuance of this change, at an accelerating rate, is a factor that must be considered. If two people can produce as much bread and cheese as six did before, it does not follow that the four others must all be thrown idle or transferred to urban industries. Some of them might be employed in growing strawberries or peaches, or in rearing turkeys.

A question of a far more difficult kind is whether the agricultural industry should be encouraged and helped to exploit to the full the possibilities of cheapening production; or how far we should deny ourselves the material advantage of cheap food in order to attain ends of quite another kind.

All economic surveys that have touched the question of large and small farms have brought out certain broad facts: that if efficiency be measured in terms of output per working hour, then the large unit has a striking advantage. On the other hand, it is equally clear that a given area of land, divided into small holdings, will tend to have a higher output, and will provide employment for considerably more workers.

Two opposite points of view are brought into sharp contrast if we compare the agricultural policies of Russia and France. In the former agriculture is regarded as an industry like other industries, and it is assumed that the whole object of agricultural policy should be to improve efficiency. To this end the old system of small and very mixed holdings must be abolished. The whole principle of subsistence farming must go, being replaced by the idea of the large factory farm, equipped with modern machinery, specialised for the particular purpose to which the land is best suited, and under the control of highly trained management. Thus it is anticipated will food be made cheap, the standard of life will be raised and new leisure will become available for all kinds of cultural activities.

On the other hand, the policy of France seems to be that the peasant must be preserved at all costs. It may be that the peasant system, as a system of food production and measured by ordinary material standards, is grossly inefficient. But the peasant is "the backbone of the nation"; he is a solid man with a stake in the country; the natural life for man is on the land, and the introduction of the ideas of the factory would destroy all that is best in rural life. Hence it is simply taken for granted that, if the French peasant cannot produce wheat in competition with Canada or Argentina, he must nevertheless be encouraged to produce wheat. At present this means that he has to be paid, by the consumer, about three times the world price.

Looking to the future, it would seem that the small farm, as compared with the large, is likely to labour under ever-increasing disadvantages. It may remain true that the small holder, working largely on a non-monetary basis, will survive periods of collapsing prices which will ruin the capitalist employer of labour. But the economic advantages of mass-production are becoming steadily greater. For instance, dairy produce, poultry and fruit are among the traditional enterprises of the small farmer; but the milking machine, the mammoth incubator and the modern fruit store are conferring differential benefits upon his large-scale competitor. Moreover, expert knowledge and skill, such as the small mixed farmer can scarcely acquire, are becoming increasingly necessary. Purchase and sale upon wholesale lines are as important as ever. It is easy to point out the material advantages of specialised and commercialised large-scale farming, and equally easy to see the sociological arguments for land settlement and small holdings. The particular form of compromise that is most appropriate remains, in the end, a matter of feeling rather than of reason.

AGRICULTURAL POLICY AND SOCIAL LIFE

JOSEPH F. DUNCAN

FROM the time of the repeal of the Corn Laws, it has been a common complaint of those engaged in agriculture that Great Britain has been without an agricultural policy. The national effort, it has been contended, has been directed towards the expansion of industry and trade, and agriculture has been left to sink or swim, with the result that it has been slowly sinking. It would be difficult, however, to make out a convincing case that agriculture was unfairly treated by successive Governments in the latter half of the nineteenth century in comparison with the treatment meted out to industry and trade. The assumption underlying the negative policy of this country in industry, trade and agriculture was that those engaged in conducting business should be left as free as possible to conduct

their affairs, and that supply and demand should be left to regulate the free exchange of commodities. As time went on it was found necessary to introduce various checks and limitations to the working of that principle in agriculture as in industry. Agricultural Holdings Acts were as much a departure from the principles of Free Trade as Factory Acts, Mines Regulation Acts, or Merchant Shipping Acts. Whatever the results may have been, the endeavour was to pursue the same underlying policy in industry and agriculture. The policy, if a negative one, was the same for industry and agriculture; the results were not the same because industry expanded rapidly in many directions, while agriculture steadily declined.

My purpose, however, is not to discuss the economic effects of this policy on agriculture, but to consider how it affected rural social life in Scotland. The justification of the policy of *laissez faire* was economic. It assumed that the strongest motive in the individual was self-interest, and that if individuals were left free to pursue their interests, and to secure the rewards of their efforts, they would work harder and the community would benefit as a result of their enlightened self-interest. All the emphasis was on individual effort and individual wealth in the material sense. "Getting on in the world" became the national ideal, and the measure of success was the bank balance. Because the adoption of this policy coincided with a period during which population rapidly increased and new countries were being opened up, into which the savings from expanding industry could be poured and to which surplus population emigrated, the bank balances mounted rapidly, and there were ample openings for individual enterprise. But in agriculture the returns were less tempting. It was shrinking, while industry was expanding. Self-interest indicated plainly that rural Scotland was not the place for those who wanted to get on, and so the vigorous and venturesome went elsewhere.

Social life is the result of group activities; it requires organisation. Where tradition is strong, and the social structure changes slowly, social life appears to go on without conscious organisation, as in the Highlands. Looking back on rural life in Scotland in the eighteenth century and early nineteenth century, it appears so to us. People were much poorer, and periods of actual shortage of food were not unknown, but there was more leisure and a fuller social life. There were numerous fairs, and work would be suspended for about a week at the Fasts, as is still the custom in some parts of the Highlands to this day. Kirns were common, and weddings and even funerals were real occasions on the countryside. Those who know their Burns, or Henry Gray Graham's *Social Life in Scotland in the Eighteenth Century*, and can compare the social life of those days with rural Scotland to-day, will agree that whatever advantages the nineteenth century brought us, we have to set against them a decay in social life. A major cause of this decay was the economic policy pursued.

That policy led to the disappearance of the small farm, the croft and the pendicle. It gathered the domestic industries into the factories, and carried away the craftsmen to the power workshops of the towns and the industrial areas. Competitive rents disrupted customary relations and forced farmers into organising their farms on business lines, and led to greater movement from farm to farm. The workers, finding more remunerative employment in industry, and tempting offers from emigration agents, kept the supply of labour short, and moved freely in the hope of bettering themselves. The urge to get on was even greater in the rural districts than in the towns, and the recognised way to get on was to get away from rural Scotland. So with a dwindling population, and a common feeling that rural Scotland was not worth bothering about, it is no wonder that disintegration of social life set in. There was no faith in the future to call forth effort from those who remained.

The sweep and pace of the economic forces let loose by the policy of *laissez faire* created a multitude of social problems in the industrial areas, which have been the major preoccupation of successive Governments in the present century. The policy was never without the opposition of various social groups, and organised opposition steadily increased, until it became strong enough to impose a variety of social safeguards. Opposition was less coherent and practically ineffective in rural Scotland, except in the Highlands, where the crofters waged a successful political fight to maintain their social life. Whether they will be able to maintain their social structure in face of economic trends is more doubtful. But in the rest of rural Scotland, organised effort was lacking until the second decade of this century. Organisations of farmers and farm workers were then formed, although their main objectives were economic. A few years later the first full effort at social organisation was the founding of the Women's Rural Institutes, and since that time other organisations for music, drama, dancing, and Young Farmers' Clubs have come into being. The period of reliance on individual effort alone seems to be closing and there is a return to organised effort in social life.

It is not a coincidence that this development in social organisation should be proceeding alongside a change in agricultural policy. The one is a natural complement of the other, and if we look into agricultural policy, we shall find that the change in agricultural policy preceded the development of organisation in social life. There is a long history now of statutory regulation of agricultural tenancies. Agricultural education and research, almost entirely financed from public funds, are a more recent development, but since the beginning of the century there has been a continuous growth of measures of one kind or another designed to assist agriculture. The approach may have been tentative and rather piecemeal, until the last few years when a definite break with the *laissez faire* policy was made in the Marketing Act of 1929 but the cumulative effect has been to impose organisation and control. The State has been definitely

assuming the place of a partner in the industry. Perhaps the most definite break with the nineteenth-century policy was in the Smallholders Act of 1911, where the State set itself to create smallholdings by the compulsory acquisition of land and the subsidising of smallholders. Following on similar legislation for the crofting counties of the Highlands, that policy was promoted more for social ends than for economic. The motive of the policy was to endeavour to retain a larger population on the land, and to provide opportunities for those for whom such opportunities were not available under a system of free competition. The Land Court cannot be advocated on any principle of Free Trade. For more than twenty years, too, we have had State assistance in promoting agricultural co-operation.

The reversal of agricultural policy has now come full circle and we are entering on a period of organisation and control. From being regarded as the most individualistic of occupations, agriculture has been selected for the most far-reaching experiment in collective control that has yet been tried in this country. Farmers have been given the power to organise marketing schemes, and if the necessary majority of producers vote in favour of a scheme, all producers may be compelled to market their produce through that scheme on the conditions laid down. Alongside this we have the control of imports, so that there is no longer a free market. There can no longer be any complaint that this country has not an agricultural policy. There may be differences of opinion as to the particular measures adopted, but all parties appear to be agreed that agriculture can no longer be left to the free play of economic forces, but that its organisation and development must be a matter of national concern.

How this change in agricultural policy will affect social life will depend largely on the particular methods adopted. If the farmers use the statutory powers given them and set up marketing organisations for most of the principal products, the changes are likely to be considerable. In farming as we have known it in the last two generations, commercial ability has been the most important factor in success. The men who have been most responsive to market needs, who have been able to make a good deal, who have, in the common phrase, had " a good eye to the main chance " have been most successful. In an agricultural system where stock has been the dominant production, and the auction mart the centre of interest, it was natural that this side of the business should be the most attractive, and that farmers should spend so much time in the market. The auction mart has been well described as the " farmers' casino." Whether this preoccupation with the fluctuating fortunes of a very unstable market has been for the good of the industry as a whole, is open to serious question, but that it has provided the chief source of interest to farmers is undoubted. If the organisation of marketing lessens the opportunities for dealing, it will remove the principal interest in the lives of many farmers. Whether a better level of prices or a steadier " pool " price will give greater

satisfaction than the individual joy of scoring over one's neighbours remains to be seen. Organised marketing ought to develop a greater community of interest and direct energy into collective channels. This will depend, however, on the extent to which farmers can organise on a co-operative basis, and make their organisations really self-governing organisations of producers. If the centres of control and management are too far removed from the producers, and they do not feel that they can exercise any real influence over the policy of the boards, there may be no real community of interest created. So far such schemes as have been promoted by farmers in Scotland have had this aspect of the matter well in view and an effort has been made to secure effective touch between the producers and the management. The point is important in the interest of rural social life. If the centre of interest is too remote from those engaged in production in rural areas, community interest will be weakened, and community interest and group activity are necessary for a healthy social life.

I would suggest, then, that in a rural society, where conditions tend towards a community interest in those engaged in its principal industry rather than towards commercial competition, we have a better chance of developing social life. If the new policy is successful in creating greater stability in the industry, that should also be helpful, because one of the most serious solvents of the rural community in Scotland has been the restlessness and instability of the population. But stability always brings with it the risk of stagnation, and there is a real danger that marketing organisation may stereotype production and make development difficult, or restrict the opportunity of entrance into certain lines of production. If that should happen it will not be for the health of the industry or of social life. Any tendency towards rigidity in the structure of the industry will be definitely harmful, because of the lack of opportunity for younger men and the absence of encouragement to the more efficient. In agriculture this danger is always greater because land is limited.

So far I have been considering the new policy as it may affect farmers, but the wage-earners are the largest class in rural Scotland. No agricultural policy yet proposed is likely to have any *direct* effect on their position. The usual assumption is that if agriculture can be made to bring a better return to farmers, the wage-earners will share in the improvement because there will be a greater demand for their labour. If the old outlets were still open for surplus farm workers into industry and overseas, or likely to reopen to the same extent as they functioned in the days before the war, that assumption would be well grounded. It was clear, however, before the depression came upon us that the old outlets were not likely to carry off the surplus workers as they had done, and he would be sanguine who could believe that demand for labour is likely to increase to such an extent as would cause a rise in wages to occur

automatically. Labour is still a commodity, and unless agricultural policy is extended to enable farm workers to organise their market as the farmers have been enabled to organise theirs, farm workers will have great difficulty in securing a reasonable standard of living as long as supply exceeds demand. Any contribution they can make to rural social life will be dependent upon a reasonable standard of living being secured, and I suggest that the securing of such a standard of living is as much a matter of national concern as the organisation of marketing, and the maintenance of reasonable returns to farmers. There can be no justification for leaving the workers to the free play of economic forces when the farmers have been given power to shield themselves from these forces.

Economic trends and national policy would appear to be setting the problem of rural social life in a new framework, and, on the whole, in a more hopeful setting. The steady decline of population is likely to be arrested, partly because the outlets are stopped, and partly because a national effort is likely to be made to develop agriculture. If the decline is stopped, that in itself will make the organisation of social life easier. People will have more interest in its organisation if they are not always thinking of how they are to get away. But it is not only in numbers that the problem will be easier; we may reasonably hope that the quality will be better for social activities. Social life is a matter of group activity, and groups flourish according to the leadership and initiative they can command. If there is a growth of community interest because of agricultural policy, that will show itself in a growth of community interest in social life, and the training in one will help in the other. But the willingness of those who are fitted to become leaders to remain will depend on the extent to which the standards of living in rural Scotland can be brought to approximate to the standards of living which can be secured elsewhere. Whether the nation will be prepared so to frame its agricultural policy as to secure something equivalent in agriculture to other industries, and to pay the price, is not yet clear.

The nation will have to pay the price for some time at least, if it means to develop agriculture. It has been paying a considerable price for more than a decade in the financing of research and experiment, and in direct subsidies to certain branches of agriculture. Whether the payments are made direct from the taxpayers through the Treasury, or by the consumers in the form of enhanced prices, they are none the less subsidies. These may be of a temporary nature, and meant to ease the transition to more economic production and marketing. But, even if agriculture should develop so that such subsidies are no longer necessary, it is more than questionable whether agriculture can ever compete with industry in the returns to those engaged in it. Yet the aim of any national policy in agriculture must consider the standard of living of those engaged in it as well as the necessities of food production, and the standard

of living ought to include the reasonable satisfactions of social life as well as the mere necessities of life.

It may be said that all that can be reasonably required of any agricultural policy is that it should provide such a standard of living as will enable those engaged in it to provide for themselves such social amenities as they need. I suggest that it is worth consideration whether this is not to place too heavy a burden on agriculture and so to load costs on the industry as to make it difficult to enable it to compete with others. Social services, whether services of health and education, or cultural services such as music, drama and the arts, are much more expensive in rural areas, yet many of these services are a public charge in urban areas, and do not fall directly on industry. In recent years housing itself has become a social charge, borne to a considerable extent on the public funds. If the national aim is to preserve rural life, it is worth consideration whether that aim would not be better served by subsiding social services in rural areas, rather than in direct subsidies to agriculture. Subsidies for social services designed to bridge the gap between urban and rural life would provide amenities which would make urban life less attractive to rural dwellers, and so weaken the attraction of the towns. They would be less open to objection because the benefits would be more evenly spread and there would be less danger of the inequalities of benefit which every form of agricultural subsidy so far has shown to be inescapable. And if the desire is to develop a rural community, it is in the development of a satisfactory social life that most lasting benefit is to be found.

GRASSLAND MANAGEMENT AND ITS EFFECT ON THE NATURE OF THE SWARD

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IT is generally recognised that the production from grassland is closely bound up with the botanical composition of the sward. All the care exercised in the compounding of seeds mixtures when land is laid down to grass gives ample proof of the farmer's faith in the relative values of the various species. Nay, the more up-to-date farmer would go even further than choosing the species. The recent strides made by the plant breeder has made it possible for the farmer to choose his favourite breeds or strains in the grasses and clovers, just as he would select any particular breed or strain for his stock of animals. Obviously this is sound practice, and the strains known to produce the maximum quantity with quality should be the ideal to aim at.

Since much of the grassland laid down recently is intended to

remain under this crop for a period of years, another important characteristic of any strain, viz., "persistency," must also be borne in mind when selecting the seed.

The care in the production of a good sward does not, however, end with the sowing, and the experiments in progress at Jealott's Hill show how the nature of the sward can be changed in any desired direction by manipulating the time and intensity of grazing.[1]

Starting with an uniform sward sown down with a general purpose seeds mixture, and fencing off plots each of which was stocked so as to vary the intensity of grazing at different times of the year, according to its own particular plan, distinct changes in botanical composition were brought about in the course of three years, as shown in Chart I.

The sward on one plot became distinctly clovery, consisting of 70 per cent. wild white clover, an adjoining plot had the grasses dominating, of which perennial ryegrass was the chief (41 per cent.), whilst a third plot was nearly all cocksfoot (84 per cent.).

A fourth plot in the same series showed a distinct deterioration in the sward due to the inroads of unpalatable weed grasses and thistles. The rapid influx and vigorous establishment of thistles was very pronounced, whereas in the three previous plots the sward was maintained practically free from this troublesome weed without any cutting at all.

In order to show that these plots were not fortuitous in their soil characteristic, a similar series of four plots were fenced off alongside and given corresponding stock grazing, their treatment differing only to the extent that they received no nitro-chalk in the spring of each year. This second series of plots bore out in all botanical respects the results obtained in the first series, and differed only in the smaller quantity of produce in the spring.

Control of the Clover Content by Grazing.—Plot 1, where the wild white clover increased, was stocked heavily with sheep throughout the main growing season—the period of plenty—so as to keep the pasture closely grazed, and then the number of sheep was reduced to a very light stocking during the winter months.

The preservation of this plot in a condition of even and close grazing throughout the summer was greatly facilitated by having it well stocked during the months of March, April and May, the close nipping of the earlier grasses at this time making their growth later on much less formidable for the stock to deal with.

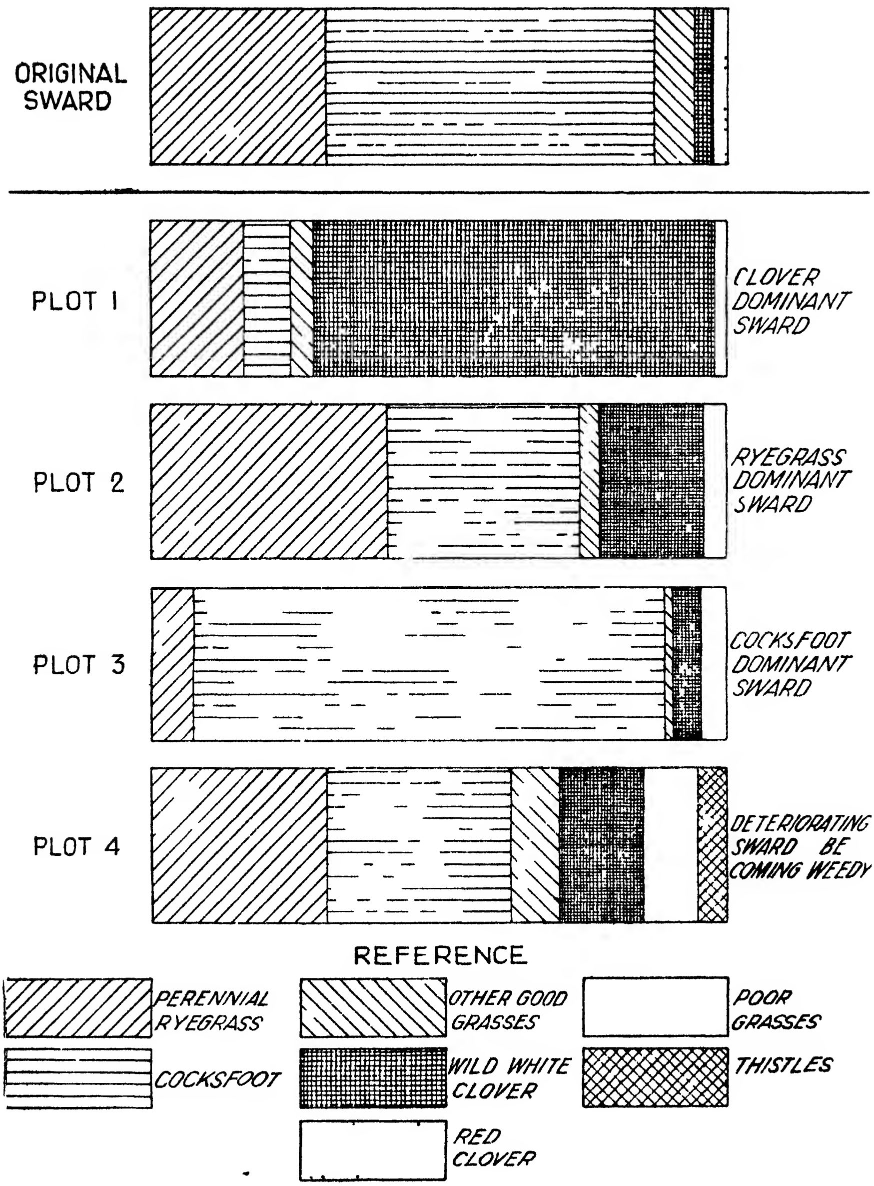
It should be remembered that plants in a sward compete with one another for their life-requirements just as much as animals do,

[1] The full data on these experiments have been published in the *Empire Journal of Experimental Agriculture*:

Vol. I, No. 1, April 1933.
Vol. I, No. 2, July 1933.
Vol. I, No. 3, Sept. 1933.
Vol. I, No. 4, Nov. 1933.

CHART I.

Showing the changes in botanical composition of the sward due to four methods of grazing carried on for three years



and, moreover, that the success of one type of plant may mean the suppression of the other.

The form of growth of wild white clover is such that its true stem never grows erect into the air, but always remains close to the soil surface. This form of growth serves as a protection to the plant from the grazing animal, as the more erect-growing plants are more easily accessible. In addition to acting as a conducting channel, this prostrate stem has the capacity to strike roots at any point throughout its entire length. Moreover, the leaves and flowers usually have very short stalks. It will, therefore, be seen that this plant is at a considerable disadvantage for competing with the more erect-growing grasses when the pasture is allowed to grow high.

The method of grazing minimised the competition from taller plants—the grasses—whilst the lessening of the winter stocking prevented the animals from being forced to scrape up and eat the succulent stems of the clover plant. Those clover stems are packed with a store of nutrition ready to supply the needs of the new growth of leaf and root in the following season. Such manipulation of the grazing in the course of three years was responsible for increasing the proportion of wild white clover to twenty times the original, the clover by that time becoming the dominant constituent in the sward.

That the increase in clover content due to the control of the grazing is not limited to young swards is shown by the response of a very old permanent sward during two year's treatment on similar lines. (See Chart II, Plot 1.) This land had been down in grass for at least twenty years, and probably for eighty years. It consisted of a mat of bent grass interspersed with Yorkshire fog and red fescue, together with just a sprinkling of white clover and the more palatable grasses. In this case the dense growth produced during the summer and early autumn had for years denied the clover the necessary opportunity for spreading at that time of the year, whilst the unpalatable nature of the produce during the late autumn and winter months served to protect and conserve the vitality of those undesirable competitors for the following spring. The chief feature of the grazing of this sward was the adequate concentration of stock on it between June and September. This prevented the unpalatable grasses from ever attaining sufficient size to cover the prostrate clover, and, in particular, reduced the vigour of the bent grass and thus checked its action in throwing out its wiry stolons in the autumn. Such stolons are particularly unpalatable and thus serve to propagate the species in the following season. Many of these stolons, though they eventually get trodden into the ground by stock, at first grow up a little and so are carried higher above the ground level than the spreading stems of white clover.

The success of this method of grazing—which by the way, in this particular case, would be rather too severe a treatment to expect milking cows or the young growing stock of either cattle

or sheep to thrive on for long—may be gauged from the fact that by the third season of its treatment the wild white clover had spread until it occupied one-half of the sward, *i.e.*, when the various constituents of the pasture were separated out the wild white clover accounted for as much of the produce as all the remaining species put together. The bent grass, on the other hand, had been checked so much that by the third season it had been reduced from its dominating position until there was little more than a trace of it left.

Plot 2 in the same series was grazed only moderately close, but that was done at all times during the main growing season other than in the early spring, no animals being turned in before the middle of May. This enabled the grasses, especially a few of the earlier ones, to attain a fair size and vigour which later on kept the clover more in check than on Plot 1.

Plot 3 was also protected in the spring until May, but at each subsequent monthly grazing enough stock were put in to graze everything off closely in a few days, the plot being given a complete rest in between the monthly grazings. The clover increased more quickly than on Plot 2 but not so rapidly as on Plot 1, with its more frequent close grazing.

It may be pointed out here that, of all the four treatments to which the permanent sward was subjected in this series, it was under these conditions—monthly rotational grazing with protection in the spring—that the useful grasses thrived best, which in itself would militate to some degree against the clovers.

Control of the Grasses by Grazing.—The grazing animal affects also the competition between plants when those plants differ in their rate of growth at various times of the year. Evidence of this was obtained on the young sward, as shown in Chart I; Plot 2 became ryegrass dominant whereas Plot 3 became distinctly cocksfoot dominant, though they had originated from the same seeds mixture on one and the same type of land.

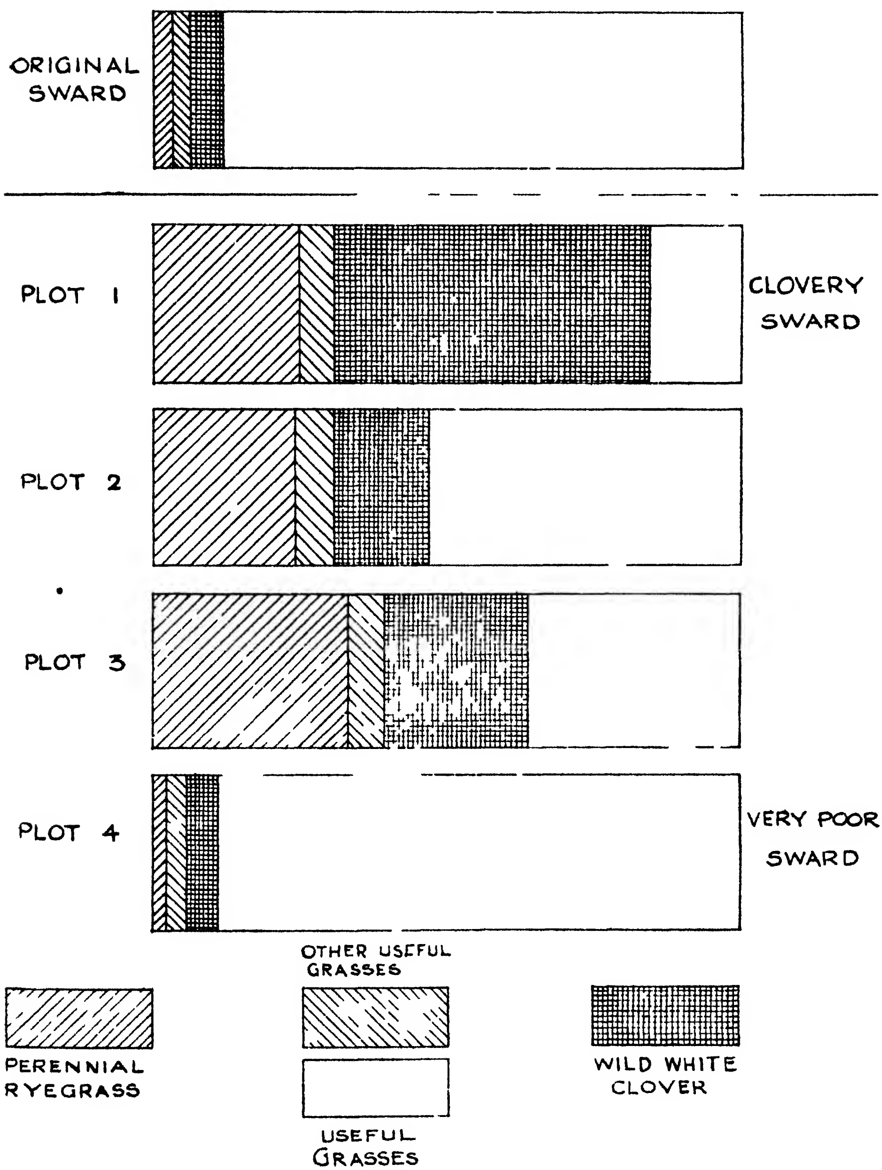
The two grasses were represented in the original seeds mixture by persistent leafy strains—Kentish indigenous perennial ryegrass and the Akaroa strain of cocksfoot from New Zealand.

The difference in the management of these plots was that the plot that became ryegrass dominant was given a complete rest from stocking each year from the beginning of March until the middle of April, and from then onwards was grazed. On the other hand the plot that became cocksfoot dominant was grazed up to the middle of April and then given a complete rest until the middle of May, being subsequently grazed in the ordinary way.

The mode of life in these grasses might, with advantage, be looked into in greater detail. Though we talk of winter as the dead season, perennial plants such as these grasses do not put a stop to all their activities during the winter months. They merely change the relative proportions of their various activities in sympathy with the environmental conditions obtaining at the various

CHART II.

Showing the changes in botanical composition of an old permanent sward due to four methods of grazing carried on for two years



periods of the year. Normally there are at least two vital processes going on within the plant; namely, a synthetic process, the proceeds of which go to increase the plant system or are stored up for future use; and an oxidation process in which the food store is broken down to release the necessary energy to maintain life in the plant.

It has been found that grasses, when utilising these synthetic products in the spring, make a somewhat corresponding increase in both the leaf system and the root system. Further, should the leaf system be suddenly reduced by grazing or cutting at that time, the balance between the aerial system and the root system will soon be readjusted, this being done partially at the expense of the root system. When such defoliation is repeated at frequent intervals it soon weakens the whole plant, and more particularly so when the plant is just putting up its first leaves in the spring—the first new wings in the factory.

When, therefore, the grazing animal removed the young leaves in Plot 3 during March and the first half of April, they were mainly those of perennial ryegrass—the earlier of the two grasses—thus weakening the ryegrass more than the cocksfoot. In the period of no grazing following afterwards for a month both plants had become active, and in the competition between them the weakened ryegrass was at a disadvantage, and that, coupled with the more robust nature of growth in cocksfoot, gave the latter the upper hand in the competition.

On the other hand, when Plot 2 was not grazed until the middle of April the perennial ryegrass, starting first, was able to gain some advantage over the cocksfoot. During the grazing that followed from the middle of April onwards the cocksfoot itself was actually at its most susceptible stage for the adverse effect of frequent defoliation, whilst the ryegrass was better able to stand it owing to the fact that it had progressed further from the most critical period.

Control of Weeds by Grazing in a Newly-sown Sward.—The fourth plot in the series referred to in Chart I occupied land similar to that of the first three plots and was originally sown with the same seeds mixture and on each occasion received the same dressing of artificial manure. The change in its botanical composition was therefore solely due to the method of grazing.

The stocking was arranged to see what would be the effect on the sward of overgrazing during the winter and early spring months followed by gross undergrazing during the summer and autumn periods, a practice frequently forced upon many farmers in various districts throughout the country.

In spite of the fact that the growth produced on this plot during each month of the year varied between the limits of sufficing for one sheep in January and February to sufficing for twenty sheep in May and June, the rate of stocking per acre was increased in

the flush season only to double the rate allowed during the lowest period in winter. From May to September the rate of stocking was approximately five sheep per acre ; for the rest of the year half that rate.

The result of this stocking was that practically every green blade was removed as soon as it appeared from the beginning of January to the end of April. The flush of growth produced in May invariably turned the balance in favour of the plants, and henceforth the sheep would not consume more than a fraction of the herbage produced until the following autumn, when the production would fall away again.

At the commencement of their spring growth the earliest grasses were therefore faced with a somewhat rigorous process of defoliation, which, coming at such a critical period in their life cycle, tended to weaken them and thus favour the establishment of volunteer plants. Eventually during the period of undergrazing the animals in their selection left the unpalatable members of this volunteer roll untouched, which in this case consisted chiefly of the creeping thistle, Yorkshire fog and bent grasses.

The creeping thistle protects itself from the grazing animal in winter by leaving only the dry withered stem above ground, its own food reserves having been transferred into its underground stems, where it remains until the favourable period for flush growth in the following May.

In the early autumn the bent grasses transfer a large proportion of their reserves into their stolons which, though above ground, are so wiry as to be avoided as much as possible by the grazing animal, the plants thus protecting themselves throughout the winter.

The protection of Yorkshire fog in the winter months is ensured by its reserves being mostly stored in the basal portion of the plant which is protected by its doubly unpalatable basal leaf sheaths, and it is only the very strongest plants of this species that put up any fresh green blades before the flush period in the following spring.

The adverse effect on the sward of severe grazing in winter and early spring together with the selective grazing exercised by the sheep during the summer months is shown by the weedy condition of this comparatively young sward. As shown in Chart I, the sward was free from any weed grasses or thistles at the commencement but, after only three years of such grazing, the weed grasses had definitely established themselves, comprising nine per cent. of the herbage, whilst the plot was badly overrun by creeping thistle.

Control of Weed Grasses in a Permanent Sward by Grazing.—How the lack of palatability favours the chances of one species over another in the competition between plants is also shown by the response to differential grazing obtained on the permanent sward (see Chart II).

The increase in clover content of Plot 1 has already been described.

This was brought about by keeping the sward closely grazed throughout the "growing" season. The contrast between this and Plot 4 is very striking. The grazing of Plot 4 was controlled so that there was overgrazing in winter and spring, but undergrazing in summer and autumn (corresponding to the treatment of Plot 4 in the series on the young sward).

On Plot 1, where the control of grazing was such that practically all the plants had to be eaten down at each grazing, the unpalatable plants soon showed signs of weakening—the unpalatable grasses and weeds being reduced in two seasons to an eighth of their original quantity, whereas on the plots where there was undergrazing throughout the flush period in the summer and autumn the unpalatable plants retained their hold on the sward without signs of any challenge.

The grazing animal by virtue of its selection removed the aerial parts of the palatable plants oftener and more completely than those of the less palatable ones. This meant a bigger check on the defoliated plants as well as a drain on their resources by way of food material stored up in their lower parts and in their root systems. On the other hand, the unpalatable plants with a good reserve of supplies were able to compete more successfully during critical periods such as the initial stages of renewed growth in the following season.

Autumn Treatment of Pastures.—Different effects on the sward were also shown by varying the time and intensity of grazing in the autumn. On a sward composed of a mixture of perennial ryegrass and cocksfoot, the constituents were so influenced that in one case the cocksfoot became more than twice as prevalent as the ryegrass, whilst during the same interval on the adjoining plot, having a similar sward originally, the ryegrass became more than twice as prevalent as the cocksfoot.

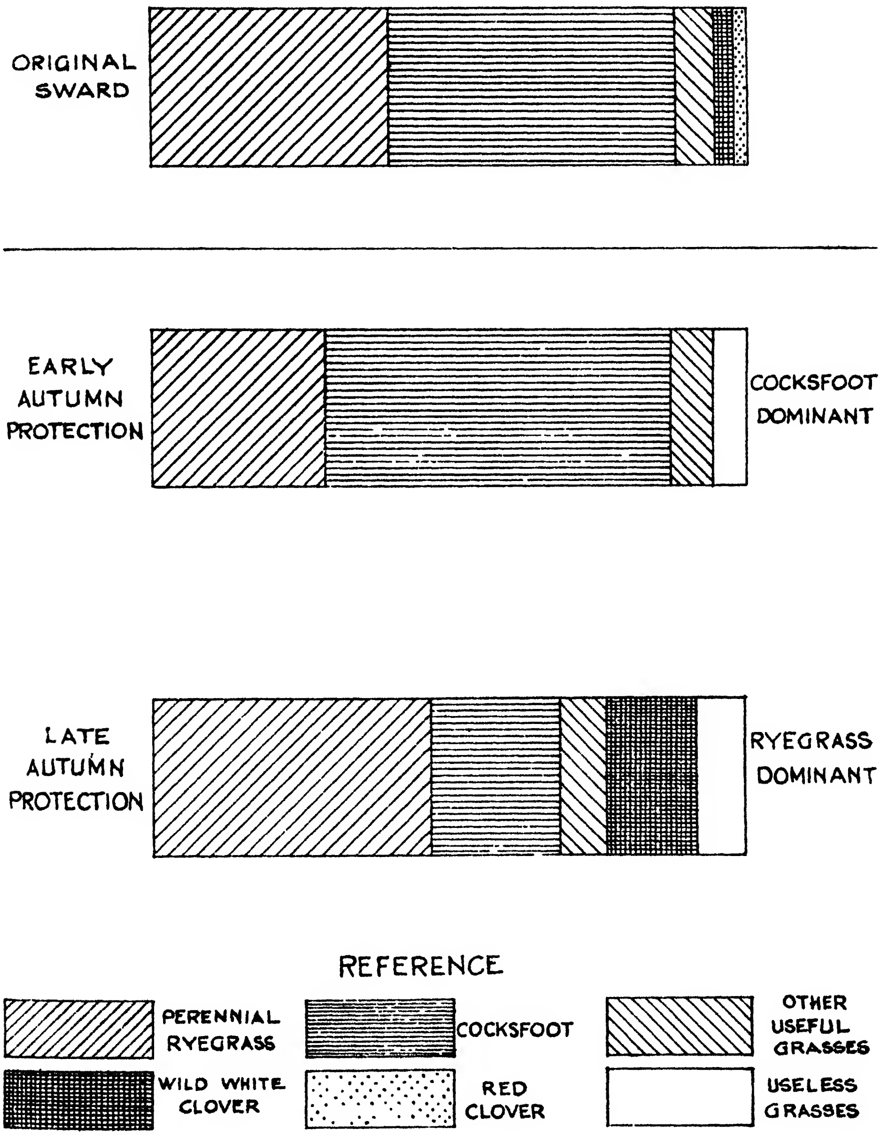
By protecting the sward in the early autumn months—grazing only once between the end of July and the middle of September—the cocksfoot content in the course of two seasons increased from 48 per cent. to 60 per cent., with a corresponding decrease in the ryegrass as shown in Chart III. The other plot was kept closely grazed during the period when protection was given to the above-mentioned plot, but was protected from grazing during the latter portion of the autumn—mid-September till the end of October. On this area the ryegrass increased from 40 per cent. to 47 per cent., whilst the cocksfoot decreased.

The management of these two plots was identical at all other times of the year, the grazing being done by the same class of stock —sheep—on corresponding dates and a hay crop taken off each on the same date.

The difference in the response of the sward on the two plots may be explained in the following manner. As the days get shorter in the autumn the seed-forming season soon comes to an end, but the

CHART III.

Showing the changes in botanical composition due to the time of autumn grazing and resting.



grass plant still continues to build up material in its leaves, which material is sooner or later transferred into the basal portion of the plant—the swollen leaf sheaths and roots—before the winter comes. These swollen leaf bases are somewhat unpalatable to stock and serve to store up this material as a reserve over the winter, eventually to be drawn upon at the commencement of the growing season in the following spring.

Cocksfoot and perennial ryegrass differ, however, in that cocksfoot makes the more rapid growth during the early autumn. Thus it suffers most from being closely grazed at that time, but, on the other hand, when protected from the grazing animal, it is the most successful competitor and is enabled to lay away the biggest store in reserve.

Perennial ryegrass scores over cocksfoot during the late autumn in being able to grow up to a later date, retaining its fresh green colour when the tips of the cocksfoot leaves are already withered away. The ryegrass would therefore derive most benefit by protection from the grazing animal at that time of the year, and this advantage, together with less competition from the weakened cocksfoot, served to give the ryegrass the upper hand in the following spring.

In farming practice the conditions suitable for encouraging cocksfoot are frequently given where the aftermath fields are not grazed until well on in the autumn, these fields being put aside to cater for the dwindling period at the latter end of the grazing season.

Similarly, conditions suitable for the encouragement of perennial ryegrass are to be found in districts where the pastures are well grazed up to September, and are then completely unstocked for the winter or made to carry an exceedingly light stock.

Seed Mixtures.—It is abundantly clear from the foregoing experiments that the seeds mixture only governs the initial take, and that the nature of the sward ultimately depends more on the treatment subsequent to sowing than on the balance of species in the mixture itself.

Yet the seeds mixture itself is most important on account of the inherent and intrinsic value of the species or strain which it will introduce and which eventually will be encouraged by the management. For instance, if a certain species is to be vastly increased as time goes on in the life of a sward, that species should be represented by the most useful strain or breed within the species.

The selection of grass and clover seed has so far not received the same consideration on the part of the average farmer as he has devoted to the selection of seed in his other crops, such as the cereals and potatoes. It is very rare for a farmer nowadays to put an order for wheat seed without stipulating the variety. A seed which is going to produce up to ten crops should therefore be considered much more carefully from its breed point of view, especially when the vast range of differences between the strains of any one grass is

considered in regard to their yielding capacity, periods of growth and quality, the latter, as shown by Stapledon and Fagan, being largely governed by the proportion of leaf to stem.

On the other hand, we must not forget that all land over which animals roam, birds fly and winds blow will at times have a certain amount of seed distributed over them of practically all the plants common to our islands, and it is necessary only for the environmental conditions to be suitably adjusted for these seeds to germinate, develop and establish themselves.

The effectiveness of cattle as agents for spreading heavy seeds of grass and clover was demonstrated very clearly during the drought conditions of 1933. In the droppings of cattle one frequently came across not only germinating oats but also seedlings of grasses and clovers, the seeds having travelled through the alimentary canal without injury and possibly in some cases rendered all the more ready to germinate. Specimens of red clover and perennial ryegrass have been found still attached to the seeds which were inside the pats of dung on the fields. Such pats of dung if left unspread for some time cause the original vegetation to die off, leaving bare spaces which the clover seedlings will be amongst the first members to colonise.

The first to colonise, however, do not necessarily hold the ground. All too frequently the biotic factor comes into play in an uncontrolled manner and the palatable colonisers are subjected to selective grazing, which weakens them and thus makes it all the easier for their unpalatable competitors to thrive.

In a similar manner these unpalatable volunteers are always ready to take the place of the plants whose seeds were originally sown by the farmer, and unless the type of plant seeded and the after treatment are mutually suitable, the inevitable result must be a replacement of those plants by the volunteer plants.

. . . .

This article has been written, not so much with a view to inform the practical man what to do to his pastures or how to deal with individual pasture fields, as to stimulate his interest in a more modern method of viewing the whole problem of pasture management under the changed and ever-changing economic phases through which agriculture, in common with other industries, is passing.

During the past half-century the history of many a district in its agricultural treatment might be summed up in that of a typical field.

Fifty years ago the field when "run out" under the drain of cereal crops would be allowed to recuperate for its future period of production by remaining fallow for a year. This practice was much commoner in England than in Scotland. At that time the conditions of farming were such that the forgoing of a year's crop, together with the spending of much man and horse labour on the land in the meantime, was the most efficient way of maintaining an equilibrium between the economic forces of production.

Twenty years later the advent of comparatively cheap sources of artificial fertilisers and the increase in the cost of labour made such a procedure uneconomic, and the same field came to be improved through the agency of a root crop.

Later still the importation of cheap grain caused a reduction in the arable area and the land was laid down to grass, to be ploughed up in future only for the purpose of reviving the fertility of the "run out" pasture. Whilst the discrepancy between the value of the root crop and the cost of producing it did not assume too great a balance on the liability side, this method of renewing the pasture by means of the plough and then seeding down afresh remained a most popular method of maintaining a reasonable balance in the proportion of good pasture to poor pasture on the typical "mixed" farm.

To-day the root crop, owing to its relatively high cost of production, is rapidly becoming a thing of the past in some districts. No longer will the field be put through that typical arable rotation merely in order to improve it as a pasture; a rotation whereby the less useful types of pasture plants were replaced by sowing down a seeds mixture of selected herbage plants in a clean soil, free from the competition of the less palatable weed grasses, and at the same time fortified by the high fertility in the form of manurial residues after the root crop.

The maintenance and also the encouragement of the better species in pastures to-day, therefore, has become a matter of greater importance than ever before, thus focusing more attention on the principles underlying the management of our grasslands.

Summary.—The value of a pasture in any particular place depends largely on the proportion of the more useful plants to the less useful plants in it, *i.e.* the botanical character of the sward. The foregoing experiments have proved that the proportions of such plants may be changed according to the way the grazing is conducted, whether the pasture had been recently seeded down or was an old permanent sward.

Since perennial ryegrass commences active growth earlier than cocksfoot and both are very susceptible to the weakening effect of early grazing, it was possible to increase either the one plant or the other at will. Under the conditions in the South of England protecting the pasture from being grazed in the early spring—beginning of March to the middle of April—increased the proportion of perennial ryegrass. Later protection—mid-April to mid-May—increased the cocksfoot.

In the autumn perennial ryegrass continues to grow later than cocksfoot. Protection in early autumn increased the proportion of cocksfoot, while late autumn protection—mid-September to end of October—increased the proportion of ryegrass.

Perennial ryegrass is particularly valuable on account of its

long growing season and high palatability throughout. Where, however, pastures have to carry the same stock all the year round, these two characteristics set it at a considerable disadvantage in competition with less useful grasses such as bent and Yorkshire fog, which have a shorter growing season and at all times are less palatable. When the good grasses are not protected in the early spring, and the pastures are understocked in summer, the less useful grasses increase at the expense of the better plants and in a few years may oust them entirely. An attempt should be made at least once every three years to give the pasture protection in the spring, together with a good close summer grazing in order to reverse this process of deterioration. For this purpose the area for grazing could be reduced during the flush seasons in late spring and early autumn, and the mower run over the remaining area, the surplus growth being made into silage.

In addition to checking the poor grasses and weeds, close grazing in summer maintains the wild white clover, the amount of which depends primarily on the method of grazing, rather than on other factors such as the supply of nitrogenous or other fertilisers.

BRACKEN AS A COLONIST

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The following article is a preliminary statement of the causes which have led up to the rapidly increased spread of bracken within the last few generations. It indicates the problems involved and the lines of study and observation being pursued or which are still required. It purposely aims at provoking discussion or, better, initiating investigation, and for that reason the author will welcome criticism—constructive or destructive.

There is little doubt that formerly bracken was a plant of very considerable value for thatching, litter and other purposes. In the south it was most frequently a woodland plant, but in the north, with the moister climate, shorter growing season and less intensive sunshine, it is more common in the open than in the woodlands. Certain trees of the forest are probably the only natural eliminators of bracken. In woods, trees like larch encourage its growth and apparently cannot subdue it, others, like Scots fir and oak, can distinctly limit it, while beech and spruce can suppress it. Often the destruction of forests gave bracken the chance to spread unchecked.

Nowadays bracken has become too abundant, and its uses have been superseded, so that, except from the æsthetic point of view, it is universally regarded with disfavour and, in fact, has become a serious problem in the economics of modern agriculture. The seriousness of the bracken menace is scarcely apparent to any who

have not a knowledge of the conditions of the hill grazings and farmlands of Western Scotland, or of the conditions in Australia and New Zealand. The problem is further complicated in Australasia by the fact that the fern may not die down during the winter.

Under British conditions it is by no means uncommon for a farmer, who forty years ago possessed 2000 acres of ground suitable for grazing, to be faced with a reduction to 1000 acres suitable for grazing to-day—a halving of the grass acreage and of the sheep-carrying powers of the land due wholly to the invasion of bracken. In some cases the bracken even threatens to overrun the last few hundred acres still available for cultivation in the bottom of the valleys, which are now being attacked by bracken from all sides.

Factors Responsible for Bracken Increase.—What are the factors which have allowed bracken to gain such a mastery? Some are economic and are fairly obvious, others are much more complex, and many are not yet fully understood. In order to give a complete picture of the situation let us first consider the uses in the past which led up to the initial increase or later kept bracken under control.

In a land where wealth was not synonymous with money the possession of bracken often led to strife. Its stout "root," or underground stem (rhizome, as it is called botanically), was in great demand for thatching purposes. It possesses a hard, black, protective "skin" and long, fibrous strands within, which make it resistant and strong. Bracken "roots" would yield a good wearing thatch which could be reckoned on for 5-6 years of wear, while heather itself, the ideal Highland thatch, would last no longer than 7 years. Even with suitable heather available the very much greater, almost rope-like, length of bracken gave it decided advantages. A statute of Edward the Third, dated 1349, decreed that "every tiler or coverer with straw or fern" should receive 3d. per day. In those days bracken was a commodity of value.

While the frond supplies a source of starch for human consumption in Japan and elsewhere, apparently it has never been a staple form of diet in this country except in times of extremity. The young, blanched shoots have been eaten, and during the war methods for cooking bracken appeared in various newspapers. It was more generally recommended for the feeding of poultry and domestic stock (4), (7), (8), (9), (14). Cattle occasionally eat small quantities of it and sheep taste it, and according to Britten (4) the dried fronds used to be mixed with hay for horses.

It used to play a very important role for litter purposes and so freed for forage all the available grass that could be spared for making hay. To a more limited extent it is still used for this purpose, and also for protecting sea-kale blanching-frames and for packing material, etc. It is, however, not an ideal litter crop, for its absorptive properties are low, though, unlike the rhizome, the frond, if exposed, quickly rots, and the old brown fronds disappear as if by magic when summer approaches. Bracken was also used

locally for dyeing purposes, and it has been recommended as a source of potash, originally for the making of soap and glass, but more recently by R. A. Berry (2) as a manure. James Britten in his *European Ferns* cites the many domestic and medicinal uses to which it was put in the past, as well as its place in the magic rites of those days. Probably the methods of harvesting it in the old days weakened the plant more than present-day methods. In those days the facility to cut bracken, like peat-cutting, was a right and an appreciated privilege. As far as I can learn, the tools available made it necessary to cut the area allotted while the frond was still comparatively green, and so a tax was placed on the fern's recuperative powers. Now, with comparatively cheap scythes, the litter is too often gleaned when the frond is dead-ripe and its removal does not harm the plant in the slightest.

How far man introduced bracken into the Western Islands is not known. In certain cases there is a story that bracken patches were initiated and protective regulations as to their subsequent treatment were laid down in the lease. The descriptions of such leases would be of great interest if any are still extant. We have a modern parallel in Breckland. W. G. Clarke writes, *In Breckland Wilds* (p. 51): "Rights of bracken cutting have survived in a few heaths as on Lakenheath Warren where there are eighty-four 'rights,' the lord of the manor holding the largest number, entitling the holders to cut brakes and sand-sedge after August 29. Each right-holder is supposed to have ten acres." It would be interesting to know when the date given originated, for it suggests that its introduction was to obviate the weakening or extermination of the bracken in regions where it is an asset and not a menace.

Coming to those factors which were once limiting, the most obvious is the depopulation of the glens and islands, attributable in part to the natural drift of the more vigorous and enterprising to places of greater opportunity, and in part to the creation of deer-forests and other sporting amenities, which bring easier modes of living to many of the natives.

More recently the demands of educationists have made life in the out-of-the-way hirsels impossible for the married man, so the solitary shepherd's house, miles from anywhere, has fallen into disrepair. The shepherd no longer dwells amidst his work, but walks uphill to it daily, in order that his children may live near school.

As one roams amidst our Scottish glens one observes many evidences of the ruins of fields and gardens, now more or less completely covered by seas of bracken. The old wall, the remains of the disused house, byre and "yaird" are all monuments to the industry and constructive enterprise of the farmers and their shepherds of the past. Less commonly, for they are often obliterated, one sees the remains of the old watercourses which were common in certain districts for flooding in order to enrich the soil and to check the too

rapid increase of bracken. As the late W. G. Smith (11) used to point out, this utilisation of the natural bases in the water and silt of hill streams is a forgotten art in modern hirsel management. These people—the farmers, crofters and shepherds—by their utilisation, or by their individual control of bracken, prevented it from being a menace in the past. It has to be remembered, however, that the bracken was still under control. To-day in the West of Scotland this is no longer the case.

There seem also to be exceedingly good reasons for blaming the curtailment of cattle-grazing on the hill-lands in favour of sheep-rearing for a great deal of the enormous spread of bracken. While cattle do not crop the grass so closely as horses may in certain patches, they eat it evenly and are not merely selective grazers like sheep. Moreover, cattle force their way through bracken areas, bruising and breaking it in the process, and it has been suggested that in this way they weaken it by exhausting it of its recuperative reserves. Their very efforts to obtain shelter from flies appear beneficial, and their dung helps to nourish the sparse grass. It is also pointed out how the weight of the beasts congesting and, as it were, harrowing and rolling the soil, helps to inhibit luxuriant bracken growth. Another factor was the human population which the cattle necessitated. These people required the best of the soil in the best positions for their own requirements, and it has been into these good parts that bracken has of late encroached with the greatest harm. Contrasted with cattle, sheep shun bracken as a general rule. They do not enter it unless it is sparse or still small. They only pass through it of necessity along definite roads unless they are "struck by maggots," when they take cover in it. Quite recently experiments with bracken grown in a garden have suggested an important reason why cattle entering bracken do so much damage. It has been found that bracken in a wire enclosure is healthier and withstands fungoid attack better than bracken in the open. This suggested how protection from movement might also be a point of importance. Experiment seems to justify this assumption. Where the frond joins the "root" or rhizome there is a narrowing of the frond, presumably a provision for easy closing when the leaf ceases to function, and in soils where the rhizome is near the surface, as so often occurs in the West of Scotland, a very small movement of the frond severs or damages some of the connecting vascular strands to the more or less complete injury of the frond. I believe that the general healthiness of thick masses of bracken is due, in addition to adequate manurial supplies, to the support one frond affords to the other. It is therefore apparent if this vital connection at the extreme base of the bracken frond can be severely injured, the result is as satisfactory as the amputation of the frond. In garden experiments I have injured the fronds by coming unintentionally against them and did not appreciate the effect of the injury until the fronds began to discolour. This point is under further investigation.

More will be said later on the inter-relation of bracken and heather, but it is clearly demonstrated that the burning of tall heather, in which bracken exists, leads to the ultimate extermination of the heather, and encourages the bracken to assume control. Notwithstanding the excellent advice on the treatment of heather in "The Grouse in Health and Disease," many keepers delay the burning of heather until it is far too old, with the result that much heather-land has been converted into bracken-land, which is worthless to the agriculturist and sportsman alike.

Bracken is kept in check by cutting, as has been clearly demonstrated by J. Milne Home (10), and noted previously in another paper (1). Gordon (5) showed the effectiveness of spraying with sulphuric acid, and more modern work has been carried out with sodium chlorate by W. G. Smith (12), by Griffiths, Evans and Williams (6), and by the present author (3). All of these operations are possible only at inconvenient summer periods, and at very considerable cost (10s. to 50s. per acre). On land clear of stones much could be done by the systematic dragging of harrows or even heavy brushwood over the still brittle unfolding fronds at a more convenient time earlier in the season. The greater amount of land covered would possibly offset the less rapid rate of extermination. All of these methods aim at exhausting the underground store of food, and money and time are wasted unless the work started is accomplished systematically, and with the utmost patience, until extermination is complete. One year missed can well extend a possible elimination period of 7 years to 10 years.

In addition, mention should be made of the value of pigs in the eradication of bracken. Their action is definite, but it requires a year or two, depending upon the growth of bracken and number of pigs allotted. All pigs will not eat it, but according to Hendrick (7) the raw rhizome is more appreciated than the cooked, and breeding sows eat it most eagerly with no harmful effects. Apparently the only drawbacks are the expenses due to fencing, protection and management, and in some cases the subsequent repair of drains and ditches. The stocking of horses and cattle is undoubtedly beneficial as a preventative, but pig-grazing can be looked upon as a cure.

Botanical Aspects.—Let us now regard bracken from the botanical aspect in an effort to assess the type of foe with which we are dealing.

Misconceptions exist as to how bracken is propagated. There are two methods, the more common being vegetative propagation by the increase from the parental subterranean stem, and later severance of this after probably many years. In this way all the patches of bracken in a locality may really be portions of a single original plant. In the autumn a large proportion of the bracken plants produce spores on the under sides of the fronds. These, grown on moist sterilised soil, produce what are known as prothalli

where fertilised egg-cells produce sporelings, which develop in the course of a few years to mature bracken plants. In nature it is the exception to find these, the reason being for the moment not very clear, but presumably the spores are devoured by organisms in the soil. J. Britten (4) and J. White (13) have already published an account of the best-known records of their occurrence, for they are so rare that few botanists have met them in the field.

Bracken is widely spread over the earth: it dates from Cretaceous times, and has relatively few fungoid and faunal enemies. During the many hundreds of thousands of years of its existence, it has proved itself so adaptable that it is one of the most successful plants of the present day. We do not know the extent and intensity of the changes with which it has had to contend, but geological evidence suggests that they have been at least very varied. It is, therefore, a bold thing to hope that any "pest" would develop now and prey so effectively on the fern that the latter would entirely succumb, or even be severely crippled, all over the world. All that one can reasonably hope for is that, in adapting itself to modern conditions, there are colonies which are leading a "C 3" existence and hence susceptible to natural as well as artificial means of destruction. A preliminary paper on a promising fungus disease was published some years ago (1), and further papers are under preparation, not only on this investigation, as far as it has gone, but also into some of the factors which make the bracken susceptible.

The Building up of Humus.—It is absolutely as essential to understand about the conditions into which a colonist is going as it is to know about the colonist himself. So, in order to get the necessary perspective of the bracken picture, and to understand exactly what are the limiting factors in the bracken problem, it is necessary to explain the evolutionary cycles which build up agricultural land. Hitherto this outlook has been rather neglected in dealing with agricultural problems.

We are apt to assume that the countryside we look out upon was the Britain that Julius Cæsar saw, or even that of the days of Robert the Bruce. Parts are still the same, but much is very different; some types of vegetation have evolved; others have retrogressed. There are three main factors which determine the type of vegetation an area can produce. The chief of these is what we call the *climatic factor*. Next in importance come the *soil or edaphic factors*, modifying any given climatic zone according to whether it is marly or peaty, rocky or sandy. Large as are the types controlled by soil conditions within the given climate, these are greatly modified by another immense group of factors collectively called *biotic or biological factors*. Some of these are obvious, others can be seen only by much observation. Grazing is an example of animals limiting the plant development. When, again, a promising crop of potatoes is severely smitten with "black blight," we have

a case of a fungus limiting the development of a crop plant. Man is probably the most destructive biotic agent, but the invisible bacteria, because of their numbers, play no inconsiderable part in modifying or altering existing conditions. A given type of vegetation is the result of the interaction or equilibrium of the major and minor factors. Hence a preponderance of bracken means that the balance of factors favours bracken development.

The world did not come into being clothed with various types of vegetation. There was growth, evolution, development in this as well as in all other natural processes. Minute algæ, lichens and mosses colonised the inhospitable rocks and soils where conditions could not support the higher types of plants until organic and other detritus had been amassed. With the evolution of the higher plants, and their marvellous powers of seed dispersal, isolated clumps at first would be formed on suitable ground, but soon the space between the plants would decrease and the biotic factor of competition would become acute. The vegetation of any site would then be a pictorial expression of the balanced interaction of the controlling factors, *i.e.*, the climate (modified by exposure, water content, etc.); the soil (modified by humus content, aeration, etc.); and various numerous biotic factors (animal and plant friends and foes).

Aim of Nature.—Further development, however, may take place. For instance, a lake may be silted up or drained and give rise to meadow-land or shrub. Left to itself the meadow-land would soon be colonised by shrubs, which, again, with favourable conditions would give way to larger trees and thence to forest, a climax being reached in the largest tree type suitable to and available for those particular conditions. *The area could not have carried these trees until suitable soil conditions were built up by preceding vegetation.* All land does not culminate in forest. Conditions may bring about a climax stage with shrubs in colder, wind-swept areas, or in heather or grasses where sheep and rabbits abound. The interacting conditions are the limiting factors, but bracken is a weed of potential forest-land.

Aim of Man.—The importance of this vegetative development cannot be over-emphasised, for all operations of agriculture and forestry are dependent upon this effort of nature to produce her highest development at any given spot. A climax vegetation is, as far as man can see in his historical period, permanent or *static*, but when man tills the soil and introduces his own crops he makes it become *dynamic* and expends or spends the soil accumulations of centuries on producing his crops. The better farmer he is the more he tries by manuring and by cultural operations to prevent depletion of the soil reserves. When the farmer grazes land, or in other words upsets the equilibrium by increasing destructive biotic factors, he again makes nature dynamic. Exhaustion of reserves is frequently overlooked in the case of hill grazings, from which for

generations compounds of calcium, nitrogen, phosphates, potash, etc., have been carted away by the ton in the form of bone, mutton, or wool.

Let us consider the features of a typical hill-pasture and what often takes place. Firstly, the climatic conditions are rigorous, wind and rain are possibly in excess and sun deficient except in the height of summer (when it is then probably excessive for the type of soil). Topography again often renders certain slopes almost sunless. Secondly, the soil conditions are often distinctly poor—cold peat, damp clays or shallow, sandy soil. Thirdly, the dominant vegetation is either sheep's fescue and fiorin, mixed with many secondary grasses and "weeds," or heather. Many of the "weeds" may be distinctly suggestive of previous woodland conditions (a highly evolved type of soil), *e.g.*, bracken, wood-sorrel, wood-anemone, violets, etc., or of previous arable cultivation, *e.g.*, daisy, buttercup, dandelion, nettles. As one ascends these "weeds" become less prominent and ultimately cease. Here and there wet portions exhibit either the presence of "flushes," with their resultant good feeding of grasses and "sprat" (or "sprett"), or the existence of areas of a bog-like nature, rush-bound, and sphagnum-covered and containing "drowned-out" bracken or heather and bog-grass.

The obvious limiting biotic factor is, or has been, man (indicated by the traces of forest removal, cultivation, drainage or heather-burning, as the case may be), or grazing animals, hares, deer or sheep. The less obvious biotic factors are various diseases on the debit side, such as heather beetle, and helpful organisms on the credit side.

The climatic conditions have just to be accepted, the soil, on account of the small value of the land, is often not worth much outlay, but the biotic conditions would often repay more consideration. Two of these are of fundamental importance—over-grazing of sheep and injudicious heather-burning.

Sheep Grazing.—Grazing animals, partly from peculiarities of their manner of eating (due to shape of mouth and arrangement of teeth), and partly from individual preference, select different foods. This can be seen by the lawn-like grazing of rabbits compared with the selective gleaning of sheep. Certain plants—like the finer grasses—are appreciated by all grazing animals, but suffer more from those that "pull" them than from those that crop them clean. In many sheep-runs the amount of pulled-out fescue is very noticeable at certain seasons. Sheep are selective feeders, and there is a danger that they may exterminate or prevent the adequate regeneration of certain plants in the herbage. As a result the plants thin out, the soil may deteriorate, and the space is taken by weeds, or if the sheep continue to be too attentive their constant treading breaks the surface, encouraging moss to develop. Heather often would develop in this moss, but as a rule the sheep give it little chance, as can be proved in many areas by the rapidity with which

it develops in "fenced-in" plots. On a limited area sheep clearly "thin-out" the herbage and prevent its subsequent regeneration with sheep-palatable foods.

The fact that sheep do not crop down all the grasses, but leave tussocks of withered sweet vernal grass and Yorkshire-fog, is also important, for the dead leaves of these smother the concealed living shoots which thus die instead of sprouting freely.

We have here a squandered heritage—a hill-pasture debased to a weedy grass-land. The weeds that invade such places are of importance. Some are themselves edible at certain seasons, like marsh-thistle and seedlings of tufted hair-grass or bullsnout which are relished in the relatively barren winter season; others, which are inedible and suffer no checks, become rampant weeds. Of these the most dangerous is the bracken.

Bracken in Attack.—Bracken is a plant which succeeds best on good deep soil and it prefers a small amount of shelter, for unless it is aggregated in large clumps it is very susceptible to damage from wind. It is popularly supposed that a patch of bracken is a colony of many individuals; but this is erroneous, for many patches consist of only the one individual plant with its many ramifying underground stems. Where we find more than one individual in the same patch, this has usually been brought about by the division of the original plant. Bracken can, under exceptional conditions, produce expeditionary underground shoots of a yard or more in length per annum and in loose sites, as in sawdust heaps, it will exceed this, but the colonising shoots are usually produced only on that side where invasion is most easy or profitable. There are many exceptions which are difficult to classify. Certain small sparse patches send out relatively few exploring shoots annually, but these may grow 2 to 3 feet. At other times the patch is stationary on one or more sides and advances only at one or two places. Again, I have marked patches which have not advanced 1 foot anywhere round the whole periphery during the past five years. Obviously a number of factors are at work which it will take many years to understand completely. In one case under observation—an old derelict farm—the bracken has advanced rapidly along the site of the earth and stone wall but makes slow progress in the old fields. The former is obviously drier, the soil less tenacious and presumably warmer: the latter is damper and the soil heavier and colder. The herbage is thinner in the drier site than where the old field used to be. It is difficult to prove that the single factor, density of turf, can hold up bracken advance, but I believe that it can. Density of turf is, however, usually the result produced by a number of factors, such as adequate moisture, foods and aeration. In another case where glacial mounds and ridges of sand appear in a peaty "moor," the drier, sandy, raised portions are noticeably bracken-clad morainic mounds, a very frequent occurrence in Western Scotland. The soil conditions, therefore, obviously encourage or

inhibit the development of the bracken. At the present stage of the investigation it is difficult to recognise all the factors responsible, but, in general, I feel no hesitation in affirming that severe sheep grazing leads to a diminution of the valuable grasses in a pasture, which, in turn, leads to a more rapid invasion of bracken and so encourages bracken domination. In a comparable way shade leads to a thinning of the grass carpet and encourages the bracken to increase, as the latter can tolerate shade better than the grass can.

Bracken increases either by enlarging its area or by thicker growth within a limited area. Sometimes the inhospitable conditions of the surrounding soil confine the bracken to the good pockets of soil and it there grows in density and size as long as supplies last. These dense areas of tall, robust bracken are a scourge recognised by all shepherds, for sheep stricken with maggots hide themselves in these from friend and foe alike. The speed at which these areas may develop is amazing. In an area at Garelochhead in 1930 there was a knee-deep growth of comparatively sparse bracken on a well-eaten turf. To-day (1933) the bracken there is waist-high and so dense that the turf is being destroyed.

Bracken in Defence.—Bracken has also its methods for defence. When it is being suppressed in woods, for example, it fights every inch of the way and it can form an outpost line. In the dark beech woods of Essex, Surrey and Sussex it can often be seen that patches of bracken exist beneath shade too dense for it to build up satisfactorily its own carbohydrates by the action of light; these are outposts pushed out between the beech trees where the moisture is greatest and the soil least root-bound, the size of the fronds diminishing as they recede from the parent plant. Some of these appear to remain in the same state for years, possibly unable to build up their own sugars due to insufficient light, but still root-absorbing outrunners. Then if by the death of a tree, or even a branch, light of sufficient intensity results to allow the outpost to become self-supporting, its rapid increase in size and vigour intimates the fact; otherwise it finally succumbs. It is less easy to be sure of the facts with bracken on the hillside, but it appears to be the case that certain outliers in uncongenial situations are being maintained at the expense of the parent patch. Sometimes these outliers cross an apparently inhospitable barrier and regain situations where they can again flourish. Most frequently they are seen invading wet, cold soil. When this is drained the bracken quickly recovers and becomes self-supporting. This is the reason why bracken should be exterminated in such areas prior to draining. Other cases are sites of "drowned bracken." Originally these were either complete bracken areas, or part of them, and by a rise of the water-table they received a check and are often obviously dying. The last stages are very interesting, for the fronds are frequently so reduced in size that they stand only about six inches high and look very like young sporelings. When dug up, the

remains of the old underground stem are traceable and the tiny branch, less than one-quarter of an inch in diameter, can sometimes be traced back to the remains of what was once a larger underground stem of two or three times this size. These vestigial remnants only require drainage of the soil to start them off again as centres of recolonisation. It is a similar state of affairs to that obtaining in woods where shade and possible drought, not water, checks the development, in some cases exterminating portions while others linger on locally. At the present time it cannot be definitely stated whether the " drowning " is due to lack of oxygen or to other physiological causes.

It will be shown elsewhere that the optimum conditions are given by adequate atmospheric moisture, and shelter from excessive winds or frost. Patches of bracken vary enormously in degree of healthiness, some making progress, others just holding their own, and still others failing and falling prey to " decline " and disease. The latter has been referred to previously (1) and will be more fully discussed in a subsequent paper.

Bracken-Invasion after Heather-Burning.—Gamekeepers often ask why it is that the burning of old heather containing sparse bracken leads to an increase of the bracken. It is easy to answer this question, for the heather is too long and woody at the time of burning, and while the heat of burning is sufficient to kill off much of the old heather, it is insufficient to harm the buried underground stems of the bracken. Competition with the heather being thus removed, the bracken can attain dominance before the heather again becomes plentiful. If the heather had been burned earlier, not only would the heat have been less detrimental to the heather plants, but these, in a more juvenile state, would have rapidly produced new growth. Recolonisation would have been from the old stools and not from seed. When heather does not regenerate freely from the stools it means that the soil is exposed for a number of years to the impoverishing influences of winter-freezing and soaking and summer-baking, with the result that surface seedlings have difficulty in obtaining a good start. The underground bracken stems in possession therefore score by reason of their favourable conditions for spreading. Undoubtedly the postponement of heather-burning until many years too late has resulted in much impoverishment of " black-land." It is more difficult to explain why bracken in heather is often sparse and remains in this condition over many years. It is presumably held in this state by the heather; otherwise it would thicken up and dominate the heather.

Summary.—An attempt has been made to show the economic importance of bracken in the past and to trace its gradual spread, resulting firstly from its use for various purposes having been discontinued, secondly from the decline of preventive measures owing to less intensive hirsel management, and later from its

actual encouragement by the failure to realise the effects of excessive grazing by one kind of stock and of the burning of old heather. The days of active utilisation of bracken are probably past, though it is unfortunate that some effective use cannot be made of this valuable source of sugar, starch and potash. Present-day economics and sparse population make the manuring, flooding and treatment of hill lands difficult, but Welsh experiments suggest that cultural methods are not impossible, and deserve consideration and trial. The success of all such advances will depend, however, on the manner in which we husband the resources of Dame Nature—the old story of the man with the goose which laid the golden eggs.

Conclusion.—Observations on many of the aspects of the growth and spread of bracken have so far been very limited or even restricted to the results obtained by one worker in only a few localities. This article has therefore been necessarily restricted to suggesting possibilities and probabilities rather than to stating definite facts. It is hoped, however, by thus directing attention to the problems involved, that others may be encouraged to contribute results of observations and experiments from many districts.

I wish to acknowledge my indebtedness and express my thanks to various estate factors, farmers, gamekeepers and shepherds for helping me to see interesting areas and for their personal observations, and also to thank Mr W. F. Burnett, M.A., B.Sc., Mr Thos. Stoddart, N.D.A., Mr John Wilson, N.D.A., and my wife for assistance in the field and for helpful suggestions.

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A FIELD METHOD FOR THE DETERMINATION OF THE MANURIAL REQUIREMENTS OF SOILS

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The growth of plants is influenced by a number of factors which control the conditions prevailing in the neighbourhood of the plants. In practical agriculture climate plays an important part, and its influence on crop production is associated with natural phenomena, such as light, heat and rainfall. Such factors, however, cannot be altered; therefore the choice and economic production of crops in any particular district are influenced to a large extent by the climatic conditions. In addition, the properties of the soil may determine the success or failure of a crop, but, unlike climate, they can often be altered sufficiently to suit the requirements of a variety of agricultural plants. Thus, for example, a wet mossy soil supporting under natural conditions a vegetation of mosses and coarse grasses, can, as a result of drainage, cultivation and the application of suitable fertilisers, be made to produce normal crop yields.

The more important properties favouring plant growth are associated with satisfactory drainage conditions, production of a good tilth and the presence of adequate supplies of suitable nutrients, all of which determine the fertility of a soil. Whilst inspection of an area usually enables the farmer to decide whether or not the first two of the above conditions are satisfactory, it does not necessarily give him much information on the supplies of plant nutrients in the soil.

The most important nutrients required by agricultural plants are nitrogen, potash, phosphoric acid and lime. These must be present in the soil in a form in which plants can assimilate them, that is, in a readily soluble or " available " form, and the amounts necessary for the complete development of any one crop vary with the plant or plants in question. For example, roots require larger supplies of nutrients than cereals; potatoes require more potash and less phosphate than turnips; barley requires more lime than oats, etc. For any crop the maximum yield in so far as plant nutrients are concerned can only be obtained when the various plant foods are present in a suitable form, and in amounts sufficient to form the nutrient balance for the crop.

In this country there exist many different soil types, formed in a variety of ways from parent materials of widely differing chemical composition. In the river valleys rich alluvial deposits are found, and as a rule these contain large reserves of plant foods. Boulder clays, formed on the retreat of the great ice sheets which once covered this country, represent a large proportion of the parent materials of our Scottish soils. When it is considered that many

different parent rocks are represented in these clays, it will readily be understood that their compositions vary within wide limits. In their unweathered state the minerals in the clays contain insoluble compounds which have to be broken down by weathering processes before they can be utilised by plants. The amount of plant nutrient in a boulder-clay soil is therefore dependent on the extent and rate of weathering, and the actual amounts of available nutrients in soils of this type are naturally less than in the further decomposed alluvial soils. In the extreme case, the peat soils have little or no mineral matter, and manures have to be added before successful cropping can be carried out.

It has been explained that, so far as plant nutrients are concerned, a balance is necessary for the successful growth of any crop, and in cases of crop failure (where drainage conditions, cultivation, etc., are favourable) it may be assumed that one or more of these is absent or present in insufficient amount. It is very rarely possible, however, to determine by observation the nature and extent of the deficiency, and as a general rule the practical farmer overcomes this difficulty by adding a complete fertiliser. Whilst this procedure is safe, it often entails increased expenditure through the addition of plant foods which are already present in the soil in sufficient amount.

It is the aim of every farmer to produce his crops in the most economic manner, and to do this he should have some knowledge of the amounts of plant foods present in his soil, so that he can, if necessary, overcome a deficiency by the addition of suitable manures. The amount of fertiliser which requires to be added in this way is known as the manurial requirement of the soil.

The manurial requirement of a soil can be estimated in a number of ways: (1) by laboratory methods; (2) by pot experiments; and (3) by field experiments.

Laboratory methods depend on the extraction of the readily soluble nutrient in the soil, and the subsequent analysis of this extract. Results of soil analyses, used in conjunction with a knowledge of climate, drainage conditions, cultivation methods, etc., can be interpreted to yield valuable information, but research has shown that no laboratory method affects the soil in exactly the same way as do the growing plants.

Pot experimental methods have been worked out on the Continent, and make use of the yields of growing plants as indications of the manurial requirement of the soil.

Suitably designed field experiments, however, can be made to give the most accurate measure of this quantity, and possess several advantages over the laboratory and pot methods. For example, the experiment is carried out under natural conditions, and account is therefore taken of the effects of climate, subsoil, drainage conditions and tilth. In addition, the field experiment has the one great advantage that it can be carried out by the

farmer himself and made to supply him with useful information about any manurial deficiencies in the soil under observation. The experiment can, however, be carried a stage further, and by weighing the yields and treating the results mathematically, an accurate measure of the quantities of nutrients present can be obtained. The mathematical treatment of the results may present difficulties to the farmer, but assistance can readily be obtained from the scientific institutes. Whilst the scientific treatment of the results is advisable wherever possible, it must be emphasised that actual observation of the experiment during the growth period—an undertaking well within the scope of every farmer—can and does give useful information.

Field Experiments.—In the laying down of the field experiment, great care must be exercised in the choice of position. Where the results are to be applied to a large area the position chosen for the field experiment must be situated in a part which is as representative as possible of the whole area. At the same time, it is often found in practice that a portion of a field is for some reason much poorer than the field in general; the laying down of a field experiment in the poor part will show whether or not the failure is due to manurial deficiency.

Generally it is found that end-rigs, sites of pits, stacks, etc., and areas bordered by trees or hedges are quite unsuitable for an experiment of this nature. The experiment may be conducted with any agricultural crop, and the size of the plots in the experiment is determined by the crop chosen. The number of plants in a given area varies considerably from crop to crop, being much greater with cereals than with roots. Since the area of a plot must be chosen so that the total number of plants is sufficiently large to eliminate errors due to blanks or irregularities, it will be seen that the size of the plots where a root crop is grown, must be greater than that in plots with cereals. The areas of the individual plots for cereals and roots are approximately $54\frac{1}{2}$ and $217\frac{3}{4}$ square feet, representing $\frac{1}{800}$ and $\frac{1}{200}$ of an acre respectively. On account of their smaller size, field experiments with cereals are simpler to conduct; the application of the manures and the harvesting present little difficulty so that, in general, cereals have a decided advantage over roots. If the seed is broadcast, the plots may be laid down in any direction, but if the seed is drilled it is necessary to lay down the plots in a row following the direction of sowing, so that any irregularities due to drilling are constant throughout.

In order to compensate for variations occurring in the soil throughout the experimental area, the various treatments have to be repeated several times; in practice it is found that it is sufficient to repeat each treatment five times. The experiments to be described have been devised by Professor Mitscherlich, of Königsberg, to determine the amounts of nitrogen, potash and phosphoric acid which are present in the soil in a form available to plants.

The mathematical treatment of the results is based on Mitscherlich's laws of plant growth. The experiment is carried out in a row of twenty plots, and consists of four sets of treatments arranged as follows :—

A A'

I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

C C'

It is thus possible to obtain five blocks each containing all four treatments.

Set I receives a dressing of potash and phosphoric acid, but no nitrogen.
Set II receives a dressing of nitrogen and phosphoric acid, but no potash.
Set III receives a dressing of nitrogen and potash, but no phosphoric acid.
Set IV receives a dressing of complete manure containing nitrogen, potash and phosphoric acid.
The plots are arranged in a row numbering 1, 2, 3, etc., up to 20.

Set I	consists of	Plots	1, 5, 9, 13, 17.
Set II	,,	,,	2, 6, 10, 14, 18.
Set III	,,	,,	3, 7, 11, 15, 19.
Set IV	,,	,,	4, 8, 12, 16, 20.

It will be seen that in the first set, where no nitrogen has been added, the plants have to take their nitrogen supply from the soil. Set IV has received a known amount of nitrogen, so that by comparing the growth in Sets I and IV it will be seen whether or not the soil shows a nitrogen deficiency. In addition, it is possible to calculate from the yields of Sets I and IV how much nitrogen was present in the soil in an available form.

Similarly, in Set II the soil has to supply the potash to the plants, and in Set III the phosphoric acid. Set IV already contains dressings of these two substances, so that by comparing II with IV and III with IV we can see whether or not there are deficiencies in potash and phosphoric acid respectively. The respective amounts of potash and phosphoric acid which were present in an available form can also be calculated from the yields obtained.

Experience has shown that for cereals a convenient size of plot is 16 feet 9 inches long by 3 feet 3 inches broad, and the results given in this article were obtained from plots of these dimensions.

With roots, the breadth of the plots depends on the width of the drills, but where this is 27 inches a suitable size is approximately 24 feet long by 9 feet broad ; this gives a plot containing 4 drills, and a total of, roughly, 100 plants.

The amounts of nitrogen, potash and phosphoric acid which are applied to the plots are as follows :—

TABLE I

		Nitrogen (N)		Potash (K_2O)		Phosphoric Acid (P_2O_5)	
		Cwt. Per Acre	Oz. Per Plot	Cwt. Per Acre	Oz. Per Plot	Cwt. Per Acre	Oz. Per Plot
Set I .	Cereals	Nil	Nil	1·6	3·6	1·4	3·2
	Roots	Nil	Nil	1·6	14·4	1·4	12·8
Set II .	Cereals	0·5	1·1	Nil	Nil	1·4	3·2
	Roots	1·0	8·8	Nil	Nil	1·4	12·8
Set III .	Cereals	0·5	1·1	1·6	3·6	Nil	Nil
	Roots	1·0	8·8	1·6	14·4	Nil	Nil
Set IV .	Cereals	0·5	1·1	1·6	3·6	1·4	3·2
	Roots	1·0	8·8	1·6	14·4	1·4	12·8

Generally the nitrogen is applied in sulphate of ammonia, the potash in sulphate of potash, and the phosphoric acid in superphosphate, but other fertilisers, such as nitrate of soda, 30 per cent. potash manure salts, and basic slag can be employed.

The dressings given above when applied in sulphate of ammonia, sulphate of potash and superphosphate are as follows :—

TABLE II

		Sulphate of Ammonia		Sulphate of Potash		Superphosphate	
		Cwt. Per Acre	Oz. Per Plot	Cwt. Per Acre	Oz. Per Plot	Cwt. Per Acre	Oz. Per Plot
Set I .	Cereals	Nil	Nil	3	$6\frac{3}{4}$	8	18
	Roots	Nil	Nil	3	27	8	72
Set II .	Cereals	$2\frac{3}{8}$	$5\frac{1}{4}$	Nil	Nil	8	18
	Roots	$4\frac{3}{4}$	42	Nil	Nil	8	72
Set III .	Cereals	$2\frac{3}{8}$	$5\frac{1}{4}$	3	$6\frac{3}{4}$	Nil	Nil
	Roots	$4\frac{3}{4}$	42	3	27	Nil	Nil
Set IV .	Cereals	$2\frac{3}{8}$	$5\frac{1}{4}$	3	$6\frac{3}{4}$	8	18
	Roots	$4\frac{3}{4}$	42	3	27	8	72

These dressings are considerably larger than would be applied in practice, and in this connection it must be borne in mind that

the experiments are not the usual manurial trials, but are devised to show up the extent of manurial deficiencies in the soil. When increasing quantities of a manure are added to a soil, the rate of increase in crop yield is not proportional to the amount of manure applied, but gradually diminishes as the dressing is increased until a point is reached where no further increase in yield is obtained. The amounts of nitrogen, potash and phosphoric acid required to produce the maximum yield are given in the foregoing table.

The procedure followed in the laying down of an experiment with cereals is as follows. A strip of land approximately 70 feet by 20 feet is selected, and, after having been sown with the rest of the field, is left unmanured. A rectangle (ABDC in sketch), 65 feet long by 16 feet 9 inches broad, is pegged off inside this strip, and two strings are run along the two sides, *i.e.*, from A to B, and from C to D. Two shorter lines are next stretched, parallel to each other, across the strip, the first from A to C, and the second 3 feet 3 inches distant at A' to C'. In this way Plot 1 is marked off, and can now be treated with the weighed amounts of fertilisers (as in Table II). The latter, which are most conveniently made up in paper bags beforehand, are now placed in a small pail, and thoroughly mixed with about 5 lb. of soil, which should not be too moist. The soil-manure mixture is then carefully and uniformly distributed over the whole area of the plot, and raked in with a garden rake. The line AB is then shifted along to the far side of Plot 2, *i.e.* 3 feet 3 inches from A'C', and the appropriate manure applied in a similar manner. The procedure is repeated throughout the twenty plots.

Observations should be made during the growing season and the growth of the plants in each plot noted. Set IV has received a complete manurial dressing and will show the maximum development obtainable by the addition of fertilisers. If no manurial deficiency exists, all four sets will show a uniform development, whilst deficiencies in nitrogen, potash and phosphate will be shown by poorer growth in Sets I, II and III respectively.

When the crop is ripe, a road is cut round the rectangular strip ABDC. A line is stretched between A'C' and Plot 1 is cut with a scythe or other suitable implement into the road beyond AC. The material is gathered into one sheaf and labelled. The line is then shifted to the outside of Plot 2 (*i.e.* 3 feet 3 inches along), which is then cut into Plot 1, gathered and labelled as before. The twenty sheaves from the plots are stooked, and when dry weighed in pounds and ounces.

In 1933 a number of field experiments of the above type were laid down on a variety of soil types throughout Scotland.[1] The results given in Table III are typical, and were obtained from a bean crop grown on carse land (Soil A).

[1] The writers wish to take this opportunity of thanking all those who gave them assistance in the field experimental work.

TABLE III

	Set I	Set II	Set III	Set IV
Plot No. .	1	2	3	4
Yield .	18 lb. 6 oz.	23 lb. 7 oz.	20 lb. 9 oz.	23 lb. 12 oz.
Plot No. .	5	6	7	8
Yield .	20 lb. 0 oz.	22 lb. 12 oz.	21 lb. 4 oz.	20 lb. 10 oz.
Plot No. .	9	10	11	12
Yield .	18 lb. 13 oz.	19 lb. 15 oz.	19 lb. 14 oz.	21 lb. 0 oz.
Plot No. .	13	14	15	16
Yield .	18 lb. 4 oz.	18 lb. 15 oz.	20 lb. 8 oz.	21 lb. 7 oz.
Plot No. .	17	18	19	20
Yield .	18 lb. 12 oz.	20 lb. 8 oz.	20 lb. 9 oz.	23 lb. 4 oz.
Mean Value	18 lb. 13 oz.	21 lb. 2 oz.	20 lb. 9 oz.	22 lb. 0 oz.

The mean values of the yield of oats obtained in two experiments which were conducted in Aberdeenshire on a deep peat soil (Soil B) and on a granitic boulder-clay soil (Soil C) may also be given :—

	Set I	Set II	Set III	Set IV
Soil B .	11 lb. 15 oz.	14 lb. 12 oz.	15 lb. 4 oz.	15 lb. 15 oz.
Soil C .	8 lb. 14 oz.	10 lb. 13 oz.	7 lb. 5 oz.	12 lb. 0 oz.

Observations were made throughout the growing season, and after harvesting the sheaves were graded according to quality. On Soil A, where the crop was beans, it was noted that early in the season all plots showed a fairly uniform development, but as time went on the plots of Sets II and IV gradually drew away from those of Sets I and III. Flowering and podding took place in Sets I, II and IV at approximately the same time, Set III lagging behind slightly. When harvested the plants in Sets I, II and IV had a similar appearance, the tops of the stalks being dry and withered, and the bean pods hard and dark in colour, whilst in Set III the beans were still green and not so well podded. In Set I the crop, although of good quality, was obviously shorter and lighter. The observations indicate that this soil is very slightly deficient in nitrogen and phosphate.

On Soil B (oats and grass seeds) the lack of nitrogen was early apparent, the plots of Set I being clearly visible on account of their yellowish colour. This difference was maintained throughout the growing season, and on harvesting Sets II, III and IV were fairly uniform and heavier than Set I. This soil is well supplied with potash and phosphoric acid, but is deficient in nitrogen.

On Soil C (oats and grass seeds) pronounced differences in the

plots were seen early in the season, and became even more noticeable as time went on. Sets I and III lagged behind to a considerable extent, and at harvesting the order was: Set IV somewhat better than Set II, both being much superior to either I or III. Here there were very obvious deficiencies in nitrogen and phosphoric acid.

From mathematical treatment of the results on the basis of Mitscherlich's laws of plant growth, it is found that the above soils contain the following amounts of available nutrients in cwt. per acre :—

TABLE IV

Cwt. per Acre	Soil A	Soil B	Soil C
Nitrogen	1·9	1·1	1·1
Equivalent Sulphate of Ammonia .	9·0	5·2	5·2
Potash	1·1	1·0	0·9
Equivalent Sulphate of Potash .	2·0	1·9	1·7
Phosphoric Acid	1·6	1·8	0·5
Equivalent Superphosphate . .	8·9	10·0	2·8

Manurial Requirements.—If a soil which is deficient in a nutrient is cropped in plots as follows: (1) without the addition of fertiliser; (2) with the addition of a fixed quantity of the nutrient; (3) with twice this dressing; (4) with three times this dressing, and so on, it is found that the difference in crop yields between Plots 2 and 1 is greater than that between Plots 3 and 2, and this in turn is greater than that between Plots 4 and 3, etc. That is, the increase in crop yield brought about by the addition of a nutrient gradually falls off with increasing amounts of the nutrient until finally the maximum yield is reached, and further addition produces no further increase. It should be the aim of the farmer to build up in the soil a reserve of nutrient which will produce a yield as near to the maximum as is economically possible. Soils already containing more nutrient than is associated with the production of this maximum yield will show no response to the addition of the nutrient until the excess has been removed from the soil by plants, drainage, etc.

In practice it is found that a close approximation to the maximum yield is obtained when 1·2 cwt. per acre potash and 1·7 cwt. per acre phosphoric acid are present in the soil. These quantities represent 2·2 cwt. per acre sulphate of potash and 9·4 cwt. per acre superphosphate respectively.

Returning to Table IV, it will be seen that all three soils show slight potash deficiencies, amounting to 0·1, 0·2 and 0·3 cwt. per acre potash. A general recommendation would, therefore, be to increase slightly the dressings of potash hitherto applied to these soils.

The three soils show considerable differences in their contents

of phosphoric acid. Soil A has a very slight deficiency amounting to 0·1 cwt. per acre phosphoric acid. Soil C, with the very high requirement of 1·2 cwt. per acre phosphoric acid, should receive, in addition to the normal dressings, as much phosphate as the farmer can see his way to apply with a view to overcoming the deficiency. Soil B, on the other hand, is already very well supplied, and a normal maintenance dressing is all that is necessary to keep up the reserve.

The effect of additions of nitrogen on crop yields is slightly different to that outlined above for potash and phosphoric acid, for in practice it is never possible to apply the extremely high dressings of nitrogen which are theoretically required to produce the maximum yield. Experiments indicate that with the possible exception of newly broken-up lea, Scottish soils are generally very deficient in nitrogen, and show a marked response to nitrogenous manuring. On account of the harmful effects which follow the application of an over-dressing of nitrogen, care must be exercised in its use. In most cases, therefore, the general recommendation is to add nitrogen (in nitrogenous fertilisers, dung, green manure, etc.) in as heavy dressings as are practicable. The nitrogen figure of 1·1 cwt. per acre in Soils B and C is low, and in these soils the addition of relatively small dressings of nitrogen will substantially increase the crop yield. Where legumes are grown, as in Soil A, it is impossible to determine accurately from the crop yield the amount of nitrogen present in the soil, since leguminous crops can utilise atmospheric nitrogen.

Several objections to the efficacy of the arrangement of the plots described have been raised by statistical workers, who hold that a random arrangement of plots is required to overcome variations in the soil. The regular arrangement of plots in a strip, however, has the great advantage of simplicity and presents little or no difficulty to the farmer.

FOUR-NIPPLED SHEEP

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In Professor Wallace's *Farm Live Stock of Great Britain*, appears a sentence calculated to arouse the reader's curiosity—" Since 1890 four-nippled ewes and rams have been collected and successfully bred at Beinn Bhreagh, Cape Breton Island, Nova Scotia, by Dr A. Graham Bell, and latterly six-nippled sheep have been developed." One naturally inquires for more particulars and wonders what commercial value, if any, these sheep have, or had, and whether they still exist. Possibly the peculiar character of these sheep, even if they themselves should have proved of little value, might have some

value, if it could be developed, in one of the good-milking breeds of this country.

Alexander Graham Bell, who was born in Edinburgh in 1847 and educated at the Universities of Edinburgh and London, was one of Scotland's famous sons, although most of his life was spent, and his work done, in Canada and the United States. His outstanding achievement was, of course, the invention of the telephone, but he was a man of true scientific outlook and his interests ranged over a wide field. He was a member of many learned societies, gave numerous addresses, and wrote many scientific papers and monographs. He was the founder of the American Association to Promote Teaching of Speech to the Deaf, and for a time was President of the National Geographical Society.

His interest in sheep arose as a result of the decision to make the family summer home at Baddeck, Cape Breton Island, in 1886. In these country surroundings a man of his character was bound to have his interest attracted to some of the phenomena of Nature; and sheep evidently soon won the chief position.

He noticed that twins occurred only occasionally in the native sheep, and he wondered whether means could not be found of increasing their frequency. He had observed, by 1890, that sheep possessing a second pair of teats, usually very small and undeveloped, occurred among the native flocks, and also that the proportion of sheep having four teats seemed to be larger among the twin-bearing ewes than among those with singles. It seemed then, that, by developing this four-nippled character, one might produce a more prolific type of ewe, which would at the same time, in virtue of having a better developed udder, yield more milk.

Dr Bell's experimental work with sheep can be taken as dating from 1890. Its objects were both practical—to benefit the local farmers by giving them bigger crops of quicker growing lambs—and scientific. At first, however, and up to 1904, Dr Bell regarded his flock as "simply a scientific curiosity." His work falls roughly into two parts: first, the attempt to fix a twin-bearing four-nippled type, all the teats being functional; and second, the attempt to go beyond this and produce six- and eight-nippled sheep. At one time he wondered whether with such ewes triplets and quadruplets would become more common.

The experimental work can also be divided into three distinct periods; the first from 1890 to 1909, when all the sheep were kept at Beinn Bhreagh; the second from 1909—when Dr Bell got rid of all sheep with less than six teats—to 1914; and the third from 1914 to August 1922, when Dr Bell died. In 1914 he decided to give up his experiments by handing the best of his six-nippled sheep to a younger man, Mr J. G. Davidson of Stewiacke, Nova Scotia, to continue the experiment, selling all the rest. The loss of their sheep, however, proved too much for both Dr and Mrs Bell, so that they made a fresh beginning. The result was what was known as

"Mrs Bell's little flock," made up of selected ewes having four or more functional teats, whose first lambs were twins.

Progress was rapid at the beginning of the experiment. By careful inquiry and examination, ewes were found among farmers' flocks on Cape Breton Island which already had four functional teats. There was thus no need to try and develop the character by persistent mating of sheep which had a rudimentary second pair of teats. In a few years the flock of four-nippled sheep at Beinn Bhreagh had become so large that reduction became necessary, and so made a severe culling possible. Once all the ewes had four functional teats, and particularly after the stage had been reached when all the members of the flock had four-nippled parents, reversion to the two-nippled type practically ceased. But there was no evidence that the flock now established was any more prolific than one with ordinary two-nippled ewes. Dr Bell, however, observed that by the autumn his twin lambs from this flock were, on the average, as well grown as the singles, and he therefore claimed to have produced a breed "which could successfully rear twins."

Dr Bell was perhaps unfortunate in his choice of material with which to start his work. The native sheep were primitive and unimproved. The winters, too, were very severe, the sheep having to be provided with shelter against storms and blizzards. Thus hardiness was a very important factor. His success might have been greater had he worked with one of the highly improved British breeds in a less rigorous climate.

He devoted a great deal of time and energy to this work as well as to many other sheep problems, and took the most detailed and painstaking records of every individual in his flock, thereby gathering a tremendous mass of data.

While developing the four-nippled sheep, Dr Bell managed to find two ewes with six teats, two teats good and four very small. But he made slow progress in developing this character; not till 1898 did he produce a six-nippled ram that he could use. Even then progress continued slow, only about 10 per cent. of the lambs born having six teats, and he could find no more of these sheep in the neighbouring flocks.

Now the troubles of inbreeding began to bother him, but he partly overcame these by lending six-nippled rams to local farmers, and buying back from them any six-nippled lambs. By 1909 this policy was proving a success, so he decided to concentrate on six-nippled sheep and got rid of all with less, distributing them free to neighbouring farmers. In 1910 50 per cent. of the lambs born had six teats, and by 1912 this had risen to 53 per cent. By the time Dr Bell decided to discontinue his work he had reached the stage of having sufficient ewes to make selection possible. The new blood introduced from other farmers had increased the health and vigour of the flock until he could claim "that there are now no better nor finer sheep than those to be found on Beinn Bhreagh."

From the literature it is difficult to form a clear idea as to the number of sheep in the flock at different times. A catalogue of the Beinn Bhreagh flock was published for the years 1890-1903, giving the pedigree and particulars of those born in these years. Presumably this includes only those which reached the weaning, or similar, stage, and not all those born whether alive or dead or which died young. In 1890 72 lambs are recorded, and the number stayed around this figure till 1894, when it dropped suddenly to 17. Then it rose gradually to 32 in 1901, 52 in 1902 and 53 in 1903. There is no indication as to how many sheep were distributed when the four-nippled sheep were dispersed in 1909 or the six-nippled sent to Stewiacke in 1914, but the numbers of breeding ewes would appear to have been quite small.

On the death of Dr Bell and his wife, who died only a few months later, there were only about 15 " pure Bell " ewes at Beinn Bhreagh, and also (if they still existed) the six-nippled ewes at Stewiacke. This was an unfortunately small number if their value was to be examined, as was desired, by any scientific institutions. In 1923 they were offered to " institutions or breeders of established reputation who are in a position to utilise in a thoroughly scientific way Mr Bell's multi-nippled breed of sheep." No doubt had the actual number available been too small, farmers could have supplied other animals, even if not absolutely " pure Bell." But from the opinions of those who obtained " pure Bell " sheep it would seem that the number they received was quite sufficient to enable them to reach definite conclusions.

Several ewes went to the Dominion Experimental Farm, Nappan, Nova Scotia. In the 1926 Report they are referred to as follows: " The Multi-nipple Bell strain is supposed to be very prolific, and the ewes, having four to six teats, are looked to as greater milkers. Unfortunately, our experience with this strain of sheep does not bear out this fact, as the following figures show." In 1925 4 Bell ewes gave 5 lambs, against a 160 per cent. crop from the pure-bred Shropshires (25 in number) kept at the farm, under the same care and management. In 1926, 5 Bell ewes gave 5 lambs, against 165 per cent. for the Shropshires. This is rather surprising, unless the Bell ewes came from Stewiacke, because in 1922, the 15 " pure Bell " ewes at Beinn Bhreagh gave 31 lambs, only one being a single. While the Bell ewes, the Report continues. " raised good grade market lambs, yet the ewes do not appear to be any better milkers than the Shropshire ewes. As this multi-nipple flock does not appear to have any economic value, it will be disposed of at the end of the year."

Other sheep went to the University of New Hampshire, Durham, where an attempt is being made to improve the Bell type by crossing with the regular stock of the University farm, viz., Oxford × Rambouillet crosses. It seems very doubtful whether much success will be obtained.

In 1932 Professor Ritzman of this University was good enough to give us two rams, one a "pure Bell," and the other a cross between the Bell type and the University stock; both had four well-developed teats. *The appearance of these animals is not impressive, particularly when compared with a good ram of a British* breed. The sea journey and the change of environment may, of course, have had an adverse effect, but against that, they have had much more generous treatment than our own rams, just to see if anything could be made of them.

They arrived in 1932 in time to serve a few of our ordinary two-nippled half-bred ewes at the end of the tupping season. The results were as follows:

Ram	No. of ewes tupped	No. of lambs with 2 teats	No. of lambs with 4 teats	Total lambs born [1]
Pure Bell . .	7	2	8	11
Bell Cross . .	4	3	2	6

The development of the second pairs of teats showed, as one would expect, considerable variation. The lambs were, of course, late, so that, apart from their small numbers, it is scarcely fair to compare their weights and growth-rate with our other lambs, chiefly Suffolk crosses. But in appearance and conformation they looked definitely inferior, so much so that it was felt undesirable to keep any to test their milking properties as ewes, or to discover how many had the second pair of teats functional.

The extent to which inbreeding is responsible for the poor quality of these two rams is not clear; probably not a great deal. The original sheep were a primitive type, and Dr Bell was not specially aiming at improving their quality. Illustrations of his flock indicate that they would scarcely commend themselves to agriculturists accustomed to British standards of quality.

The chief reason why no more has been heard of these multi-nippled sheep appears to be that they could not stand practical comparison with other breeds; this arose from Dr Bell's working with an unimproved type, from his various changes of policy during the experiment, the small numbers he could deal with, and the difficulties he encountered during the course of his work.

The six-nippled udder is unlikely to have any practical possibilities; four functional teats will give as much milk as any ewe can be expected to give; in fact many would say two teats were ample. But should we accept the rather disappointing results of Dr Bell's experiments without testing the value of the four-nippled character in high quality sheep?

The districts where this character might prove of value would be those engaged in intensive lamb-raising. And these districts may well have to spread if flocks of breeding-ewes are to maintain their present position in lowland agriculture. The need for more

[1] Includes 2 dead lambs whose teats were not recorded.

twins is constantly emphasised. As they increase, so will triplets, often to-day regarded by the shepherd as definitely undesirable, and that is where an udder with four teats may prove superior to one with two: the three lambs will be able to feed simultaneously, instead of taking it in turns, in which case the weakest suffers.

Our problem thus resolves itself into two parts: (*a*) to see whether a good four-nippled type of ewe can be developed, and (*b*) to discover whether they have any advantages as mothers compared with two-nippled ewes, especially if the latter have been graded up, according to actual performance, for milking properties. Many two-nippled ewes already have an udder so big and so well developed that it would be hard to improve on it. There is also the question as to which of these alternatives will give the quicker results with the less labour.

This second part presents a difficult problem, demanding time, and the scanty data so far available are not encouraging. But the first part is apparently fairly simple. Most flocks of Scotch half-breds, it is believed, contain ewes with four functional nipples. (This probably applies to other breeds as well.) In our two flocks, recruited originally from the Scottish autumn sales, out of some 300 ewes, 5 were found with four well-developed functional teats, and 18 with them reasonably well developed but not functional. Others had a rudimentary second pair.

With the co-operation of one or two farmers, a flock of 12 ewes, all with four functional nipples, was collected in 1932. (I should be very glad to hear from other farmers who could let us have more sheep, preferably half-breds, with this character.)

In the spring of 1932 our F_2 Scotch half-bred lambs (out of Scottish born half-bred ewes tupped by a good bought-in half-bred ram) were examined and a promising ram-lamb saved that had four teats. This ram was used on our ewes in the autumn, and the result was that out of the 19 lambs examined (out of a total of 22 from 11 ewes), every one had four teats, most of the second pairs quite well developed.

Thus the development of this character, if it prove desirable, should be easy. But comparing the lamb weights in 1933 of the four-nippled ewes with those of the two-nippled, there was no sign of the former being more prolific or better milkers. That does not mean that a superiority might not be developed with time and careful selection. One four-nippled ewe, unfortunately only one, deserves special mention, as her triplets weighed 112 lb. (40, 35, and 37 lb.) when six weeks old, although receiving ordinary treatment like the rest of the flock.

The ewe is frequently criticised by economists for giving a slow and small capital turnover, so being relegated to the hills and the cheapest land. But a ewe like the above is different; in fact, even a twin-bearing ewe does not put up a bad show. She herself may weigh 140 lb., and her two lambs together 20 lb. at birth, which represents

nearly 15 per cent. of her live weight. A sow weighing 400 lb. may have a 25 lb. litter (10 pigs), representing only about 6 per cent. of her live weight, while an 1100 lb. cow may have a 90 lb. calf (8 per cent.). In eight weeks' time the ewe's lambs may together have put on 70 lb. of live weight, whereas the sow's litter has put on perhaps 250 lb. Thus weight for weight, considering too the amounts of food eaten, the sow may, if anything, be slightly more efficient ; but, even if, in the same time, the cow has given enough milk to produce 200 lb. live weight gain in calves, weight for weight this compares very poorly with the ewe.

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Notes from Agricultural Colleges

Craibstone

Potatoes, 1933.—After a snowstorm in February and heavy rain in the beginning of March the soil was raw, so that no planting could be done until the middle of the month. After this time, however, the soil conditions became excellent, and planting was done under ideal conditions in record time. Although rainfall during April, May and June was slight, the plants looked vigorous until July when many varieties showed signs of wilting. The following were the earliest in this respect—Early Pink Champion, Arran Rose, Sharp's Victor, Arran Crest and Royal Kidney.

Those planted under the following conditions appeared to suffer most :—

1. Early varieties.
2. Large setts.
3. Whole setts.
4. Planted close in the drill.
5. Planted early.
6. Sprouted.

The likely reason for this is that under these conditions the plants, being in most cases earlier than usual, used up the soil moisture earlier and perhaps more completely than under normal conditions. It did not follow, however, that the crop in every case varied according to the appearance of the shaws. In fact, one point that has been consistently demonstrated every year in these trials is that the appearance of the shaws has given no indication of the yield.

In one trial sprouted and unsprouted seed of Di Vernon, Kerr's Pink and Golden Wonder were planted at fortnightly intervals, beginning at the middle of March. With all three varieties the plants from the sprouted seed which were planted earliest were by far the smallest and appeared to suffer most from the dry conditions.

In the case of Di Vernon, they were very dwarf and spreading, and were ripe and the shaws entirely down very early, at a time when the latest planted, and especially where unsprouted, were quite fresh looking. While there was in each planting a difference between the shaws of the sprouted and unsprouted, it was most marked in the case of those planted on 16th May. The unsprouted were upright in habit and about 9 inches taller than the sprouted, which were also much more spreading. The difference was so great that one might readily have concluded that they were of different varieties.

With both Kerr's Pink and Golden Wonder the later planted ones, and especially when unsprouted, were much more vigorous in appearance than the early planted ones, being about 4 feet high as compared with about 2 feet for the latter. When the tubers were lifted and weighed, however, it was seen that the appearance of the shaws was no true indication of the yield, as the following figures show :—

Di Vernon

	Ware		Seed		Small		Total	
	tons	cwt.	tons	cwt.	tons	cwt.	tons	cwt.
Sprouted—								
March 16th .	4	14	4	12	1	2	10	8
April 1st .	6	7	3	4	0	18	10	9
,, 16th .	7	7	3	2	0	18	11	7
May 1st .	6	11	3	2	0	16	10	9
,, 16th .	4	17	4	17	1	3	10	17
Unsprouted—								
March 16th .	5	2	4	0	1	0	10	2
April 1st .	5	18	2	16	1	0	9	14
,, 16th .	5	7	3	19	1	0	10	6
May 1st .	5	17	2	17	0	10	9	4
,, 16th .	4	1	3	9	0	16	8	6

Kerr's Pink

	Ware		Seed		Small		Total	
Sprouted—								
March 16th .	6	18	6	13	0	18	14	9
April 1st .	5	3	5	19	1	6	12	8
,, 16th .	7	8	5	10	1	3	14	1
May 1st .	4	17	5	3	0	18	10	18
,, 16th .	5	3	4	15	0	18	10	16
June 1st .	4	19	3	16	0	14	9	9
,, 16th .	3	1	4	7	1	6	8	14
Unsprouted—								
March 16th .	5	2	5	6	0	19	11	7
April 1st .	3	12	6	10	0	18	11	0
,, 16th .	3	13	5	17	1	6	10	16
May 1st .	3	9	4	19	1	1	9	9
,, 16th .	4	5	4	14	0	14	9	13
June 1st .	2	4	4	7	0	18	7	9
,, 16th .	1	2	1	10	1	14	4	6

Golden Wonder

	Ware tons	Ware cwt.	Seed tons	Seed cwt.	Small tons	Small cwt.	Total tons	Total cwt.
Sprouted—								
March 16th .	5	17	8	15	2	0	16	12
April 1st .	6	16	7	15	1	10	16	1
,, 16th .	6	16	6	2	1	5	14	3
May 1st .	4	17	5	17	1	10	12	4
,, 16th .	5	14	4	14	0	15	11	3
June 1st .	3	12	4	17	1	10	9	19
,, 16th .	3	12	4	2	1	10	9	4
Unsprouted—								
March 16th .	4	15	6	8	1	5	12	8
April 1st .	4	4	6	8	1	3	11	15
,, 16th .	4	17	5	12	0	15	11	4
May 1st .	4	7	5	12	1	10	11	9
,, 16th .	4	7	4	7	1	0	9	14
June 1st .	2	19	4	2	1	10	8	11
,, 16th .	1	0	4	2	2	5	7	7

With Di Vernon there was very little difference in the yields of the sprouted seed planted on the different dates, except that those planted on 16th April were best, while in the case of the unsprouted the May plantings were poorest.

With Kerr's Pink and Golden Wonder the earliest plantings were generally best, except in the case of the former where the 1st of April planting of sprouted seed was poorer than that planted in the middle of that month.

It is often considered by growers of "seed" that the largest yield of this per acre is obtained by late planting, and many consequently delay operations until well into May; but this opinion is not borne out by these results.

The average weights obtained from the sprouted and unsprouted setts were as follows :—

	Ware tons	Ware cwt.	Seed tons	Seed cwt.	Small tons	Small cwt.	Total tons	Total cwt.	Increase tons	Increase cwt.
Sprouted—										
Di Vernon .	5	19	3	15	1	0	10	14	1	4
Kerr's Pink .	5	7	5	3	1	1	11	11	2	8
Golden Wonder	5	6	6	0	1	9	12	15	2	10
Unsprouted—										
Di Vernon .	5	5	3	8	0	17	9	10		
Kerr's Pink .	3	7	4	15	1	1	9	3		
Golden Wonder	3	16	5	5	1	4	10	5		

As has always been the case, well-sprouted seed gave an increased yield, especially with the late varieties. There would undoubtedly have been a larger proportion of ware-sized tubers in the country this year had more of the seed been well sprouted before planting.

Seed of different sizes (6 oz., 3 oz. and 1½ oz.) of the same three varieties were also planted. The amount of seed planted was at the rate of 60, 30 and 15 cwt. per acre. Half of each size was sprouted, and half unsprouted. The average results obtained from five plots of each size of tubers were as follows :—

Di Vernon

	Ware		Seed		Small		Total		Total Less seed required	
Sprouted—	tons	cwt.	tons	cwt.	tons	cwt.	tons	cwt.	tons	cwt.
Large, 6 oz. .	5	6	4	10	1	3	10	19	7	19
Medium, 3 oz.	6	8	3	13	0	16	10	17	9	2
Small, 1½ oz.	6	3	2	19	0	12	9	14	8	19
Unsprouted—										
Large, 6 oz. .	5	1	3	14	0	19	9	14	6	14
Medium, 3 oz.	5	19	3	10	0	17	10	6	8	11
Small, 1½ oz.	4	6	2	13	0	11	7	10	6	15

Kerr's Pink

Sprouted—										
Large, 6 oz. .	6	18	8	1	1	9	16	8	13	8
Medium, 3 oz.	6	8	7	17	1	6	15	11	14	1
Small, 1½ oz.	7	5	4	10	0	14	12	9	11	14
Unsprouted—										
Large, 6 oz. .	3	10	7	12	1	10	12	12	9	12
Medium, 3 oz.	5	3	7	8	1	3	13	14	12	4
Small, 1½ oz.	5	3	5	4	0	18	11	5	10	10

Golden Wonder

Sprouted—										
Large, 6 oz. .	5	12	7	11	1	15	14	8	11	8
Medium, 3 oz.	5	19	6	4	1	4	13	7	11	17
Small, 1½ oz.	6	9	4	17	0	13	11	19	11	4
Unsprouted—										
Large, 6 oz. .	3	19	6	18	2	3	13	0	10	0
Medium, 3 oz.	4	12	5	14	1	2	11	8	9	18
Small, 1½ oz.	5	12	3	14	0	13	9	19	9	4

It will be seen that (1) after deducting the amount of seed the medium setts generally gave the best return, (2) the small seed produced the largest proportion of ware-sized tubers, and (3) the large seed especially when sprouted produced the largest amount of seed size.

It is well known that large tubers are obtained when the seed is planted widely apart in the drill. A trial to combine this effect along with the size of setts was made with several varieties. The results were similar with the different varieties and those with Golden

Wonder are given below. The setts were all sprouted and were 6 oz., 3 oz. and 1½ oz. respectively, and three plots of each size at each distance were planted.

Per Acre

	Inches apart	Ware tons	Ware cwt.	Seed tons	Seed cwt.	Small tons	Small cwt.	Total tons	Total cwt.	Seed required tons	Seed required cwt.	Total less seed tons	Total less seed cwt.
Large—													
6 oz.	12	2	0	6	14	2	0	10	14	3	0	7	14
,,	18	2	9	5	19	1	17	10	5	2	0	8	5
,,	24	3	4	5	2	1	4	9	10	1	10	8	0
Medium—													
3 oz.	12	2	14	5	18	1	12	10	4	1	10	8	14
,,	18	3	9	4	9	1	2	9	0	1	0	8	0
,,	24	5	2	3	5	0	17	9	4	0	15	8	9
Small—													
1½ oz.	12	4	5	4	2	0	16	9	3	0	15	8	8
,,	18	6	5	2	12	0	11	9	8	0	10	8	18
,,	24	5	19	2	2	0	8	8	9	0	7½	8	1½

Most ware was obtained from small setts planted comparatively wide, while most seed was obtained when large setts were planted close. The relative value of each method will depend on what is wanted.

A question often asked is, " Is it advisable to cut the shaws sometime before lifting in order to obtain more seed-sized tubers and to prevent the tubers growing too large ? "

On 29th August, the shaws of six plots of Golden Wonder were cut, other three being left uncut. Three of the cut plots were lifted at once and the remaining plots were lifted on 16th October. The average results from the three different methods were as follows :—

Per Acre

	Over 2⅛″ tons	Over 2⅛″ cwt.	2⅛″–1¼″ tons	2⅛″–1¼″ cwt.	Under 1¼″ cwt.	Total tons	Total cwt.
Shaws cut and potatoes lifted 29th August	0	8	8	16	16	10	0
Shaws cut 29th August and potatoes lifted 16th October .	1	16	9	12	13	12	1
Shaws uncut and potatoes lifted 16th October	2	7	9	19	11	12	17

So far as Golden Wonder is concerned, it would appear to be of no advantage to cut the shaws beforehand, as this reduced the total crop somewhat. What has apparently happened is that all the tubers have become somewhat larger, there being a larger quantity of ware and a smaller quantity of chats when the shaws were uncut.

Although the season was dry and not suited to the spread of blight, this disease appeared at the beginning of August, and soon the shaws of most of the early varieties and a few of the second earlies were affected. A few small showers were sufficient to enable it to spread and soon all the earlies were down. Dry sunny weather, however, prevented its spread to the later varieties. The extremely dry condition of the soil no doubt prevented the tubers becoming affected to any extent except in a few varieties. The following are the varieties that were affected and the percentage by weight of affected tubers:—

	Per cent.		Per cent.
Duke of York	4	Epicure	8
Arran Scout	9	Herald	3
Ninetyfold	16	Ballydoon	10
Arran Pilot	3	Abundance	5
Arran Comrade	12	Immune Ashleaf	1
British Queen	12	Mein's Early Round	20
Sefton Wonder	1	Dargil Early	1
Arran Rose	1	Edzell Blue	1
Entente Cordiale	3	Catriona	4
America	6	Great Scot	2

All other varieties were entirely free.

Several plots of King Edward, Up-to-date and Kerr's Pink were sprayed with the following different materials on 7th August and again on 6th September:—Bordeaux Mixture, Bouisol, Dry Spray, Eau-Celeste. A number of plots was left untreated.

The first spraying showed no effect, as the untreated plots remained fresh and green; but in the middle of September it was seen that all the untreated plots were affected with blight and became black and withered, while all the treated plots were quite fresh. When lifted, however, it was found that only a very few tubers were affected with blight, owing to the extremely dry nature of the soil which kept the spores from developing. In all probability had there been heavy rain about that time the tubers would have been affected. Unfortunately, tubers from the different plots were not kept separately, so that any after-effect in storage could not be observed.

There is no doubt that the prevalence of blight this year in the country generally, especially with Kerr's Pink, was due to infection at that time. The spores must have been present when the crop was lifted and have affected the tubers, which, on being put into the pits, heated somewhat and gave off moisture. This hotbed condition enabled the spores to germinate and multiply.

A number of tubers badly affected with scab was collected, treated with several mercuric preparations and planted. When the crop was lifted there was no sign of scab on any of the tubers, whether treated or untreated. This, of course, did not prove that

the materials were useless, but only that the soil conditions were not favourable to the development of scab. It has been observed that scab is worst where subsoil has been turned up. Possibly the prevalence of scab in some cases may be due to tubers having been grown in soil which had been ploughed deeper than usual, such soil being often deficient in organic matter, a condition supposed to be favourable to the development of scab.

The trials with artificial manures carried out here during the past few years indicate that the following mixture, when planted after a grain crop and along with a dressing of dung, gives the most economic result :—

1½	cwt.	sulphate of ammonia	per acre.
3½	,,	superphosphate	
1	,,	muriate (or sulphate) or potash	

Plots in duplicate were laid down with several variations to compare with the above mixture: (2) increasing nitrogen, and (3) increasing nitrogen and potash. A mixture mentioned in the South as having given good results was also tried (4).

	S/A cwt.	Super cwt.	M/P cwt.	Ware tons	Ware cwt.	Seed tons	Seed cwt.	Small tons	Small cwt.	Total tons	Total cwt.
1.	1½	3½	1	5	4	7	5	1	2	13	11
2.	2½	3½	1	5	3	7	16	0	19	13	18
3.	2½	3½	2	4	19	7	16	1	2	13	17
4.	3	3	3	5	6	6	18	1	2	13	6

The extra cwt. of sulphate of ammonia increased the crop by 9 cwt. per acre, and this result was obtained this year in another trial of a similar nature. In previous years, however, there was generally no increase. The extra cwt. of potash did not result in a further increase, while the south mixture gave a rather smaller return.

Another trial was made in duplicate with 4 cwt. and 6 cwt. of the new concentrated manure (No. 2), which was compared with mixtures made up to the same chemical composition. The results obtained were as follows :—

	Ware tons	Ware cwt.	Seed tons	Seed cwt.	Small tons	Small cwt.	Total tons	Total cwt.
1. 4 cwt. concentrated manure	5	8	7	2	0	18	13	8
2. 2 cwt. S/A, 2½ cwt. super., 1½ cwt. M/P	5	6	7	4	0	17	13	7
3. 6 cwt. concentrated manure	5	4	6	14	0	16	12	14
4. 3 cwt. S/A, 3¾ cwt. super., 2¼ cwt. M/P	5	0	6	12	1	0	12	12

There was practically no difference between the crop obtained from the concentrated manure and the made-up mixture, whilst the heavier dressing of both gave reduced yields.

Auchincruive.

Raw and Pasteurised Milk for Calves.—A preliminary trial on this question has already been reported in this *Journal*, and it is now proposed to give a report on a more extensive trial conducted at the West of Scotland Agricultural College during 1932-33, with a total of 35 dairy calves.

The calves were all from the same herd and each was brought into the trial at birth. There were 5 groups of bull calves and 5 of heifers, with 3 or 4 calves in each group. Winter and early spring calves formed 3 groups of each sex, while the remaining groups were made up of later calves.

The winter calves were kept in the trial for 150 days, and the later calves for 120 days. All calves were to be fed the raw milk of their own dams for a definite number of days after birth and then to be put on to the mixed milk of the herd, which was fed raw to some groups, and after pasteurisation to others. Details regarding the groups are given in Table I.

TABLE I

Grouping of Calves

Group No.	Sex	No. of Calves	Dam's Raw Milk fed	Raw or Pasteurised Milk later	Time on Trial
			Days		Days
I.	M.	4	10	Raw	150
II.	F.	3	10	Raw	150
III.	M.	4	5	Pasteurised	150
IV.	F.	3	5	Pasteurised	150
V.	M.	4	10	Pasteurised	150
VI.	F.	3	10	Pasteurised	150
VII.	M.	3	5	Raw	120
VIII.	F.	3	10	Raw	120
IX.	M.	4	5	Pasteurised	120
X.	F.	4	10	Pasteurised	120

Each calf, with the exception of a bull in Group I, had the raw milk from its own dam for 5 or 10 days after birth. This calf received colostrum from another cow as his own dam died at the time of parturition. After the colostrum-feeding period the calves were given the mixed milk of the herd, either raw or pasteurised.

Pasteurisation was carried out by the holding method at 145° to 150° F. for thirty minutes, with immediate cooling. The raw milk was fed immediately after milking, while the pasteurised milk was heated to 96° F. before feeding.

The milk was fed at the rate of 1 lb. for each 10 lb. live weight until the calf reached 150 lb. From this point on the allowance was kept at 15 lb. per head daily.

Other Feeds.—From three weeks of age onward the calves were given all the hay they would consume, and an allowance of grain composed of equal parts by weight of whole maize, whole oats, nutted linseed cake and wheat bran. The calves had access to water bowls at all times.

Live-Weight Gains.—The calves were weighed at birth and every ten days thereafter, and the live-weight gains have been summarised by thirty-day periods in Table II. The gains are given as the percentage increase in live weight from birth.

TABLE II

Percentage Increase in Live Weight from Birth

Group No.	Dam's Raw Milk fed	Raw or Pasteurised Milk later	To Days of Age 30	60	90	120	150
	Days		%	%	%	%	%
		Bulls					
I.	10	Raw	36	95	174	258	364
V.	10	Pasteurised	37	99	176	257	349
III.	5	Pasteurised	29	81	151	237	330
VII.	5	Raw	38	107	183	272	..
IX.	5	Pasteurised	32	91	165	244	..
		Heifers					
II.	10	Raw	35	98	169	258	341
VI.	10	Pasteurised	33	98	177	263	360
IV.	5	Pasteurised	31	93	167	256	351
VIII.	10	Raw	36	92	163	238	..
X.	10	Pasteurised	35	95	170	256	..

From Table II it will be seen that the pen of winter bulls on raw milk throughout made a live-weight gain of 364 per cent., while those on raw milk for 10 days before going on to pasteurised milk gained 349 per cent. and those on raw milk for 5 days gained only 330 per cent. The results with the spring bulls on raw and pasteurised milks are similar.

In the case of the heifers the results are somewhat different. It will be noticed that the heifers on pasteurised milk start out with lower percentage increases in live weight than do those on raw milk, but those getting the milk from their own dams for ten days before going on to pasteurised milk catch up with the raw milk heifers by the time they are two months of age, while those getting their own dam's milk for only five days take four months to reach the same level.

Protection Against Disease.—One of the most interesting points in connection with this trial was the fact that scours and other troubles were most prevalent in the groups which received colostrum

for five days only before being put on pasteurised milk. Colostrum contains antibodies which give the calf protection against disease, and every calf should receive colostrum for the first few days of life, though the optimum length of time has not yet been determined.

Musk Rats in Scotland

A YEAR has elapsed since the first trapper was appointed by the Department of Agriculture for Scotland to destroy musk rats. Before describing the habits of these animals as observed during this year, and detailing the operations for their destruction, a few facts concerning their appearance in Scotland may be recalled.

In 1927 six pairs of musk rats were purchased from Canada and installed in a field near Feddal, close to Braco, in Perthshire. Although part of this field was turned into a swamp by diverting into it the water of a burn, the musk rats disliked these quarters, and soon bit through the wire-netting by which they were surrounded and escaped. Five pairs escaped but later a male was found dead, so that the stock from which this country has since been populated by these animals was five females and four males. Eighty musk rats were killed by one keeper before operations were begun for their extermination. Rewards were paid to private individuals for 60 musk rats killed by them during the winter of 1932-33. Since October 1932 over 750 musk rats have been killed by the trappers employed by the Department. We know, therefore, that 890 musk rats have been killed during the last three years, all descendants of the few that escaped in 1927.

In the autumn of 1929 they were first noticed in a marsh on the lands of Ardoch. Sixteen mounds or "lodges," made of aquatic plants pulled up by the roots and placed in a heap by these animals, were found. In the same winter burrows made by them were discovered in Carsebreck, and yearly since then their ravages in the banks of this loch have had to be repaired at a considerable cost. Since 1930 these animals have spread rapidly over the centre of Scotland, and the rivers Forth, Teith, Earn and Allan are seriously infested by them. All the small tributary streams in the valleys through which these rivers flow, as well as any ponds, lochs, marshes and even ditches in their vicinity, are liable to harbour musk rats

Food.—Musk rats are vegetarians, though doubtless, like many rodents, they will eat flesh or fish if driven to it by hunger or if they have the opportunity. A musk rat trapped in the Forth had in its gullet a trout four inches in length. A few days after a shoot near Carsebreck a duck partly eaten was found in a musk rat burrow. They also devour fresh-water mussels. In winter they feed on the roots of rushes and water-lilies, the white portion of the stems of reeds, bulrushes and grasses. American pond weed is a favourite

diet, but they also eat other weeds which grow in our ponds. In marshes they make holes through the carpet of roots to enable them to procure those of the larger marsh plants and of rushes. It follows, therefore, that in winter they must house themselves near an assured food supply—*i.e.*, near a marsh, a pond with weeds in it, or a backwater where there are weeds, bulrushes or water plants.

In summer they eat, in addition to all the above-mentioned foods, many annuals which grow in damp places or on the banks of ponds, ditches and streams. Grass also becomes their food, so that they are able to find sustenance anywhere. Musk rats appear to be able to smell or taste food in the water which flows from a marsh or reedy pond a great distance away. There seems to be no other explanation of their appearance in a marsh 1100 feet above sea-level and five miles up a burn inhospitable from their point of view, or in a narrow ditch running through a marsh with a stony, rocky burn connecting it with the main stream.

Housing Habits.—Musk rats desire dry, warm quarters in the winter. To achieve this end they build "dens" or "lodges" in marshes and dig burrows in the nearest dry bank. They can burrow five to ten yards into alluvial soil in a night. These burrows may be fifteen yards in length but all the spoil is extruded at the entrance, it is never brought above ground. The entrances, of which there may be three to six or more, are always under water; a steep overhanging bank is a favourite site for an entrance. Lodges are frequently connected with a burrow in the adjacent bank, the connecting track being through the liquid mud beneath the lodge. There are usually two entrances under water to a lodge but no visible entrance. These "lodges" appear to be stores for food as well as alternative residences; the chamber in those examined in Scotland was found to be too small to contain the eight or ten individuals of which we know the musk rat family in winter to consist.

In summer, when the marshes become dry and the water leaves the backwaters, musk rats forsake these haunts and make for the rivers. Here they will be found near a food supply and where there is water deep enough to cover the entrance to their burrow. They dislike swift-flowing water, so that the neighbourhood of a quiet reach is an attraction to them. Even though there is food, deep water and a soft bank to burrow into, however, such a spot may remain untenanted while a little distance up and down stream there may be several burrows. This strange circumstance has been noticed in Germany also.

Migration Wanderings.—Musk rats wander great distances. Besides the enforced migration due to the drying up of their habitat, the spring and autumn migrations have been well marked by the increase in the number of animals killed compared with the number trapped at other seasons. The spring migration began in February and continued until the middle of March, followed by a decrease in

the kills till August, September and October, when the number increased most markedly; for several weeks the number killed per week averaged nearly thirty. But these animals exhibit also a strange propensity to wander far afield. One was killed at Glamis, another just to the west of Dundee and a third near Newburgh in Fife. The animal at Glamis must have entered the Tay from the Earn, travelled up the Tay and the Isla and thence into the Dean Water at Glamis. It is known that they enter the Tay from the Earn as several have been trapped at the mouth of the latter river. There is also a record of one being caught in the Tay in the seine nets of the salmon fishers. This specimen was a great disappointment to the fisherman, who took it to the Police Station expecting to receive a reward of 5s. Unfortunately for him it was caught one day too late, as the rewards ceased to be paid on 1st April!

Careful examinations of the waterways between the Earn and Glamis failed to reveal any colonies, or even signs, of musk rats. There is no apparent reason why the animal killed at Glamis should have left the hospitable locality of the Earn and travelled so many miles upstream against a strong current. No explanation can be given of the appearance of the specimen killed near Dundee. These two cases are clearly due to a "wanderlust" natural to musk rats. The musk rat killed near Newburgh was doubtless making for Lindores Loch.

Musk rats are known to have escaped at Glenbervie, Melrose and Thornhill (Dumfries). Some from Glenbervie and Melrose may still be at large, but careful examinations in both districts have failed to disclose any signs of the animals. At Thornhill the two that escaped have both been accounted for.

Areas.—For administrative purposes the country infested has been divided into ten areas—Bridge of Earn, Crieff, North and South Auchterarder, Carsebreck, North and South Stirling, Gargunnock, and North and South Thornhill. The Rivers Earn and Forth are the boundaries between the double areas. The remaining boundaries are roads, streams or arbitrary lines at the foot of the hills. There is a trapper in each of the above areas and shortly some of the areas will have two trappers. The duty of the trapper is to survey every ditch and piece of water in his area, to locate musk rats and then to trap them. Three other areas have been delimited—Perth, Callander and Lennoxtown. A few musk rats were caught at Callander. One was killed near Lennoxtown and a burrow was discovered in this area, but in neither of these areas were they found latterly. The trappers were therefore withdrawn. In the Perth area no musk rats were discovered, but the one killed at Glamis must have passed through this area. These localities are examined occasionally for reinfestation. So far no signs of their reappearance have been found.

Traps and Trapping Methods.—Before trapping operations were started a leading firm which specialises in the manufacture of

traps was consulted and a trap was evolved which has proved most efficient. This trap is smaller than the usual jaw trap, has plain bevelled jaws set ⅛-inch apart and a chain 3 feet long. The trap had to be small to permit of it being set within the burrows; the jaws are bevelled and set ⅛-inch apart so that when sprung they would only hold the leg of the animal and not cut it off; the long chain was to allow the trap with the animal in it to reach sufficiently deep water to drown. Many other types of jaw traps are in use, including circular jump traps and Canadian double-jaw traps, but the majority of our traps are of the type described above, known as No. 191 N.B.

Roith's Traps.—Our trappers are also supplied with the various traps used by Herr Roith, the chief trapper in Bavaria. These, and especially his cage traps, are very useful in suitable localities. His method consists in finding a burrow and blocking all the entrances except one or two. A cage trap is placed at each of these entrances. The musk rats are then driven into the cages by probing the burrows with a specially-made iron rod. This method has its limitations where the burrow may be too deep to be reached by the rod or where the ground is too hard to admit of probing sufficiently. Fireworks have also been used to drive musk rats out of their burrows, but they have not proved a success. Endeavour is made to lay jaw traps in burrows or where domestic animals cannot reach them, but during the periods of migration those set in runs or in "slides" at the edge of a stream have accounted for many of the captures. Several musk rats—and one vole—have been caught by the tail; recently one left the tip and all the skin off its tail in the trap. Unless the musk rat is caught well up the leg, is drowned by the weight of the trap, or drags the trap far into the burrow, it usually escapes by twisting off the foot held in the trap. Animals have been caught with two feet missing.

Elusiveness.—Elusiveness is the most striking feature of musk rats. They are nocturnal in their habits and extraordinarily shy; the entrances to their burrows are invariably under water and if there is any current the spoil extruded is carried away by it. This renders it necessary to examine suitable places frequently and very closely. As such places are often situated where the water is too deep for wading, a physical difficulty is added to the natural difficulty of locating their burrows. Their presence can be detected by the pieces of vegetation nibbled and left floating in the water, but as they may feed 100 yards away from the burrows this indication is not always of much assistance. The difficulty of detecting the presence of musk rats is considerably increased by the tracks left by waterfowl, geese, ducks, water voles and rats at the water's edge, or in marshes and pools. Musk rats prefer to swim rather than to walk, so that their spoor is seldom seen. Where all these water-loving animals use the same slide or road to enter and leave the water, it is almost impossible to decide whether it is being used

by musk rats. In such places the only definite clues are the droppings. To search for this evidence in a marsh indicates the difficulty of locating the animals. Trapping musk rats is not nearly so difficult or tedious as trying to find their burrows. To enable the trappers to find these deep burrows, two boats have been provided and three more will soon be in service. Punts will also be placed in larger backwaters. Surveying goes on continuously.

Habitat.—Musk rats cannot live in many parts of Scotland and will not live in others. Their requirements are as follows: (1) Water; they are aquatic animals and must have water sufficiently deep to cover the entrances to their burrows. (2) Food; there must be a sufficient supply of food near at hand either in the water, in the shape of pond weed, or growing at the water-side in the form of reeds, bulrushes or other aquatic plants. (3) A dry bank to burrow into. Where these three conditions obtain, there musk rats will be found. In marshes they make their dry bed in the lodges they build.

Is the Campaign a Success?—It may be asked whether musk rats are increasing or decreasing or whether they are being held in check. It is, of course, impossible as yet to give a definite answer to any of these questions. In a year or two comparison of the numbers killed will indicate which way the campaign is going. Meantime, two facts seem to point to a certain measure of success. One is that so far as is known—and surveys over an extensive area have been made—these animals are not spreading throughout Scotland; the second is that, with more trappers and intensive methods, certain areas which used to be seriously infested now harbour no musk rats and in other areas trappers report that they are distinctly fewer in number.

Reviews

Agriculture. Professor James A. S. Watson and Mr James A. More. Third Edition, 1933, 778-xii. pp. Oliver & Boyd. 15s., by post 15s. 9d.

Good evidence of the worth of this book is the fact that a third edition has been called for within ten years of its original publication. It may be described as a dual-purpose book, for it is at once a comprehensive manual for students and a compact encyclopedia for farmers. To write such a book cannot be easy, but, as the previous editions showed, the authors have succeeded admirably in presenting both the scientific basis and the practical application of their teaching. A rarer combination which they have achieved is that of scientific accuracy with lucidity of expression and the minimum of technical jargon; when, for example, the symbol pH has to be used, they wisely relegate the explanation of its meaning to a footnote, which the student may assimilate if he must, and which the more fortunate reader may ignore if he wish.

A good deal of re-writing has been done and some substantial additions have been made to the previous edition, notably a chapter on farm poultry—an excellent little treatise of an eminently practical kind. So far as a single reviewer can judge a book that covers such a variety of subjects, all its sections have been brought thoroughly up to date. The reader will find a discussion of the merits and demerits of the combine harvester, of which the authors seem to have a full knowledge based on experience; a reference to Mr Hosier's hay-sweeps; information about the A.I.V. method of making silage—a method that as yet is only on trial in this country; brief but sufficient notes embodying the latest knowledge about virus diseases of potatoes; an account of the most recent work of the geneticists, etc., etc. Specially well done are the sections of the book dealing with live stock. There are few even of the most experienced stock-keepers who could not learn something new and useful in these chapters, and for the beginner, say in pig-keeping, all the essential knowledge is supplied.

In these days when accepted practice has so often to be modified and systems of farming have to be changed to meet changing economic conditions, this is a book that it would well repay many farmers to consult; there is hardly any aspect, technical or financial, of their complicated business on which it does not give accurate information and wise guidance. As the name of the publishers would lead one to expect, the print, paper and binding are all of first quality.

Recent Advances in the Study of Plant Viruses. Kenneth M. Smith, D.Sc., Ph.D. J. & A. Churchill, London, 15s.

The economic importance of virus diseases is very much better realised to-day than it was even a decade ago. Particularly is this so in connection with plants—*e.g.* the potato—which are vegetatively propagated. There is no subject that confronts the grower, however, in which there is greater difficulty in obtaining information: an enormous literature has accumulated on these diseases, but practically all of it is scattered in various scientific papers of many countries. The appearance of a book, therefore, which assembles all the available information is greatly to be welcomed, and the value of this particular publication is considerably increased by the fact that it is not merely a compilation, but is written by a distinguished research worker and contains much original material.

The author deals with his subject primarily from the theoretical and philosophical standpoint. In the opening chapters are discussed the general nature of viruses, symptomatology and physical properties, a knowledge of all of which is necessary for the study of the problems. Chapters V, VI, VII, and part of VIII deal with

the relation of insects to viruses, and make very good reading. It is interesting to note that one aphid, *Myzus persicae* Sulz., is associated with thirteen plant viruses. In discussing the transmission and spread of viruses, the author draws attention to the relative scarcity of the virus-transmitting aphid *M. persicae* in certain Scottish seed-potato districts. Apparently, however, the natural method of spread of some viruses, including some potato viruses, is as yet unknown. Chapter IX deals with the physiology of virus diseases in plants, and will appeal mainly to the research worker. The remainder of the book, which includes sections on the "carrying power" of infected plants, resistance, immunity, the composite nature of some virus diseases, and virus diseases of the potato and of plants belonging to various natural orders, will appeal to all readers interested in the general subject.

The chapter on the virus diseases of the potato will have special interest for Scottish readers, and constitutes without doubt the best exposition of the subject we have yet seen. Horticulturists will find the virus disease of the plants with which they are particularly concerned ably discussed in Chapters XIII and XIV.

The author has not set himself the task of discussing particular methods of controlling plant virus diseases. On the general subject, however, he states :

"Investigations into methods of control of virus diseases affecting economic crops should be largely directed towards the production of varieties resistant or immune to the virus concerned and some progress in the production of virus-resistant crops, notably sugar cane, appears to have been made already."

With regard to potato varieties, Dr Smith suggests that the apparent resistance of some varieties may be largely mechanical, and for some reason or other the plant is avoided by the insect vector. This view has indeed been expressed before, but coming from such a successful investigator it must now be treated seriously. Dr Smith is of opinion that plants do not develop immunity to virus diseases, although certain species of plants do appear to have a natural immunity to a specific virus which affects other closely-allied members of the same group.

The book, which contains 423 pages, has a list of general literature at the end of each chapter ; there is a glossary of terms used in virus studies and a useful index. The numerous illustrations are excellent, and the matter is clearly and concisely put. The book is one that may be recommended without hesitation to research workers, teachers and all those engaged in up-to-date crop production.

Schemes under the Land Drainage (Scotland) Act, 1930

River Annan.—Owing to the obstruction caused by what are known as the Dormont Rocks, situated on the River Annan near Dormont House (4½ miles S.S.E. of Lockerbie), flooding occurs above that point, and the consequent damage has for many years been the subject of local agitation. The Department have now, in virtue of their powers under the Land Drainage (Scotland) Act, 1930, framed a scheme for the removal of this obstruction and the improvement of the bed and banks of the river and certain of its tributaries, by which it is expected that nearly 1,800 acres of land will benefit. The estimated cost of the scheme is £5,400, including £990 awarded to Colonel Carruthers of Dormont as compensation for loss arising from the scheme. The amount recoverable in respect of improvement to the land affected by the scheme is £4071. It is estimated that the maintenance of the works will cost £130 per annum. The scheme has now received Treasury sanction and the approval of Parliament, and the work has begun. This is the first scheme under the Act to be brought to the point of action.

River Nith.—The neighbouring River Nith is the subject of another scheme. Here the flooding is due to a quite different cause. For some miles above Dumfries the river has long been lined with flood-banks. A breach in the bank on the east side, 4½ miles north of the town, has gradually been widened, with the result that a large area of land and the village of Kirkmahoe have suffered seriously from flooding, especially during the last two winters. The Department are now preparing a scheme for preventing this in future.

The Scottish Agricultural Securities Corporation, Ltd.

After prolonged negotiations, the Scottish Agricultural Securities Corporation, Ltd., was formed early last year by the Royal Bank of Scotland, the British Linen Bank, the Commercial Bank of Scotland, Ltd., and the National Bank of Scotland, Ltd., in terms of Part I of the Agricultural Credits (Scotland) Act, 1929, and began its operations on 1st September 1933. The share capital of £100,000 is held equally by the four Banks, and the Department, with the approval of the Treasury, have advanced a further £100,000 for the purpose of establishing a guarantee fund; this advance is to be free of interest for sixty years. The Department will also pay for ten years £1750 annually towards the Corporation's working expenses.

The Corporation makes loans on the security of agricultural land to an amount not exceeding two-thirds of the certified value of the subject at the time when the loan is made, and also makes

loans in accordance with the terms of the Land Improvement Acts. At 13th December 1933 it had made, or agreed to make, loans amounting to £134,900, and had under consideration further applications amounting to £102,000. On that day the Corporation invited applications for £500,000 of 3½ per cent. debenture stock at £95 per cent., and the issue was very largely over-subscribed.

Allotments for the Unemployed

In continuation and extension of a scheme operated by them in 1932, a Joint Committee of the Scottish National Union of Allotment Holders and the Society of Friends carried out a scheme in 1933 to enable wholly or partly unemployed persons to obtain and cultivate allotment gardens. The scheme provided for the supply of seeds, seed potatoes, fertiliser and tools at approximately half cost price, payable by instalments, the balance being met by the Joint Committee out of funds raised by public subscription amounting to £3363, supplemented by a grant of £1500 from the Development Fund. From these resources the Joint Committee were able to meet all applications for assistance at a cost of £4220 for seeds, etc., a considerable proportion of which is being recovered from the allotment holders in weekly instalments.

The Department also made grants in many cases for the equipment of allotment grounds with fencing, water supply, etc.

The applications for assistance came from all parts of Scotland, but, as was expected, the largest numbers were received from urban areas where unemployment is more widespread and the need is greater than in the less industrialised districts. Altogether, 8884 persons received assistance, and of these over 6000 took up allotments in 1933 for the first time. Much of the success of the scheme was due to the voluntary services given by many of the secretaries of existing allotments associations, through whom the distribution of the supplies was carried out.

The results show clearly that, where a certain measure of assistance is forthcoming, there is no lack of readiness or enthusiasm among unemployed workers to make use of this means of increasing the family supplies of fresh, wholesome food and at the same time improving their own physical and mental condition.

The Government have announced their intention of making a grant towards a scheme on the same lines which the Joint Committee are arranging to carry out in 1934, and which, they hope, will provide for 20,000 allotment holders.

Labour on Scottish Farms

The Agricultural Returns collected on 4th June 1933 give the following numbers of workers employed on that date on holdings exceeding one acre in extent. The occupiers of holdings, their

wives, and domestic servants are excluded, but other members of the occupiers' families are included.

	Regular Workers	Casual Workers
Males, 21 years and over	59,028	6,998
Males under 21 years	19,228	3,789
Total . . .	78,256	10,787
Women and girls	17,807	5,615
Total . . .	96,063	16,402
Grand total . .	112,465	

The grand total is 1208 above that recorded in 1932, regular workers are less by 766, but casual workers have increased by 1974. Of the regular workers, men over 21 have increased by 151 or 0·3 per cent., but males under 21 have decreased by 673 or 3·4 per cent. Women and girls regularly employed have decreased by 244 ; male casual workers are more numerous by 2657, but female casual workers are less by 683.

The decrease in the number of regular workers since 1921, the year when annual returns of labour began to be made, amounts to 7808 or 7·5 per cent. Men over 21 are more numerous by 216, while the numbers of those under 21 have diminished by 4059, and women and girls by 3965. All classes of casual workers show lesser numbers employed, the total in 1933 being fewer than in 1921 by 8599.

Acreage under each Variety of Potatoes in 1933

A statement is printed on pages 104-6, showing the acreages under certain varieties of potatoes in Scotland in 1933, as returned by growers of one acre or over. These returns cover 134,637 acres out of the total acreage of 152,513, the difference as in previous years being chiefly accounted for by the total exclusion of certain districts in the Highlands and Western Islands, and by the exclusion of holdings on which less than one acre is grown. The total acreage shows an increase of 3974 acres as compared with 1932, and the acreage included in the returns of varieties shows an increase of 2975 acres.

The area under First Earlies, 17,900 acres, is greater by 3227 acres or 22·0 per cent. than in the preceding year. Epicure, with 9759 acres, or 1076 acres more than last year, accounts for 54·5 per cent. of the total, as against 59·3 per cent. of the total in 1932. Sharpe's Express takes second place this year with 2684 acres, and is greater by 753 acres or 39·0 per cent. than in the previous year. Of the remaining twelve varieties specified as First Earlies nine show increased acreages.

Second Earlies, with a total acreage of 15,192, exceed last year's total by 88 acres. Great Scot, with a decrease of 238 acres, covers 8810 acres or 58·0 per cent. of the total area under Second Earlies, as against 60·0 per cent. last year. British Queen, with 3894 acres, shows an increase of 94 acres and accounts for a further 25·6 per cent. of the total area. The areas under Royal Kidney, Ally and Edzell Blue show increases, but decreases are recorded in the acreages of Arran Comrade, King George V. and Catriona.

The area under Maincrops, 101,545 acres, shows a decrease of 340 acres. Kerr's Pink, with 56,739 acres, has decreased by 5364 acres or 8·6 per cent., but retains the first place, accounting for 55·9 per cent. of the whole area. King Edward VII. is again second with 14,188 acres, 1927 acres more than in the preceding year. Majestic and Golden Wonder, with 11,116 acres and 8822 acres respectively, are the varieties showing the next largest acreages. The variety Dunbar Cavalier, with 1971 acres, shows an increase of 1261 acres or 177·6 per cent. Arran Banner, with an area of 1795 acres, 621 acres more than last year, comes next in order of area under the crop, while Arran Chief, with an acreage of 1729 acres again records a decrease. The Up-to-Date group shows a further decrease this year of 208 acres. The acreages in some of the other varieties show fluctuation, but the areas under the crop in these cases are relatively small.

Varieties immune from wart disease cover in all 94,519 acres or 70·2 per cent. of the total area classified; non-immune varieties cover 39,165 or 29·1 per cent., while the varieties not specified in the statement account for only 953 acres. The percentage of immune varieties is less than last year by 2·8 per cent., and that of non-immune is greater by the same amount.

STATEMENT showing the Acreage under each variety of Potatoes in Scotland in 1933.

A. *First Earlies*

Variety	Acres
1. *Arran Crest†	39
2. *Arran Pilot†	63
3. *Dargill Early	82
4. *Di Vernon	71
5. *Herald †	67
6. *Immune Ashleaf	67
7. *Snowdrop (including Witch Hill)	87
8. Beauty of Hebron (including Puritan)	104
9. Duke of York (including Midlothian Early and Victory)	1,827
Carry forward	2,407

Variety	Acres
Brought forward	2,407
10. Eclipse (including Sir John Llewelyn) . .	2,383
11. Epicure	9,759
12. May Queen	215
13. Ninetyfold	308
14. Sharpe's Express	2,684
15. Other First Earlies not specified above . .	144
Total . .	17,900

B. *Second Earlies*

16. *Ally	421
17. *Arran Comrade	231
18. *Ben Lomond	258
19. *Catriona	111
20. *Edzell Blue	325
21. *Great Scott	8,810
22. *King George V.	226
23. British Queen (including Pioneer, Macpherson, Maid of Auchterarder, etc.)	3,894
24. Royal Kidney (including Queen Mary) . .	675
25. Other Second Earlies not specified above . .	241
Total . .	15,192

C. *Maincrops*

26. *Sutton's Abundance (including Culdees Castle, Kerr's New White, Twentieth Century, Just in Time, etc.)	624
27. *Arran Banner†	1,795
28. *Arran Consul†	1,144
29. *Arran Victory	307
30. *Bishop	83
31. *Champion	419
32. *Crusader	25
33. *Dunbar Cavalier	1,971
34. *Early Market	38
35. *Golden Wonder (including Peacemaker) . .	8,822
36. *Irish Queen	124
37. *Kerr's Pink	56,739
38. *Langworthy (including Maincrop and What's Wanted)	220
39. *Majestic	11,116
40. *Rhoderick Dhu	101
Carry forward	83,528

Variety	Acres
Brought forward	83,528
41. *Tinwald Perfection	133
42. Arran Chief	1,729
43. Field-Marshal	459
44. King Edward VII. (including Red King)	14,188
45. President (including Iron Duke and Scottish Farmer)	61
46. Up-to-Date (including Dalhousie, Factor, Glamis Beauty, Scottish Triumph, etc.)	879
47. Other Maincrops not specified above	568
Total	101,545
Total area classified	134,637
Acreage not included	17,876
Total acreage grown	152,513

NOTES:—

1. The following districts are excluded:—In the County of Inverness: Skye, Harris, North and South Uist; in the County of Ross and Cromarty: Western, South-Western and Lewis.

2. Returns showing a total of less than one acre under potatoes are not tabulated.

3. Varieties marked thus * are immune from wart disease.

4. Varieties marked † have been registered by the Department of Agriculture for Scotland as new varieties.

Agricultural Returns, 1933

THE Abstract of the Agricultural Returns printed on p. 140 shows that the total area under all crops and grass amounts to 4,613,708 acres (a decrease of 8509 acres as compared with 1932), the arable land being less by 16,083 acres, while the area under permanent grass has increased by 7574 acres. Rye-grass and other rotation grasses and clover have decreased by 33,956 acres, the increase in the area under other crops being thus 17,873 acres.

The total area under the cereal crops is 998,612 acres, being 6061 acres more than in 1932. The area on which wheat was grown shows an increase of 26,314 acres or 50·5 per cent, while oats and barley show decreases of 11,517 acres or 1·3 per cent and 9060 acres or 13·2 per cent respectively. The combined area under wheat, oats and barley is 994,051 acres, and shows an over-all increase of 5739 acres above the area returned in 1932.

Mixed grain, rye and beans show increases of 156 acres or 9·7 per cent, 168 acres or 6·4 per cent, and 298 acres or 10·9 per cent

respectively. The area under potatoes is larger by 3974 acres or 2·7 per cent, and turnips and swedes by 3189 acres or 0·9 per cent. Sugar beet shows an additional area of 1041 acres under the crop, having increased from 665 acres in 1932 to 1706 acres this year. There is little variation in the area on which cabbage was grown. Rape shows an increase of 1286 acres under the crop ; while vetches, tares, etc., for fodder, show a decrease of 719 acres or 7·9 per cent. The figures for flax show a partial recovery from the reduction which occurred last year, and the area grown has advanced from 13 acres in 1932 to 44 acres this year.

Rye-grass and other rotation grasses and clover show a decrease of 33,956 acres or 2·2 per cent, the area for hay being less by 5619 acres or 1·4 per cent, and that for pasture by 28,337 acres or 2·5 per cent. The area under permanent grass shows an increase of 7574 acres or 0·5 per cent, the extent grown for hay increased by 12,459 acres or 7·5 per cent, but that not for hay decreased by 4885 acres or 0·3 per cent.

The returns of live stock show that horses continue to decrease in number, sheep are also less numerous this year, while cattle and pigs show increases. Horses used for agricultural purposes are fewer by 1810 or 1·6 per cent, while unbroken horses have increased by 290, and "other horses" by 906, thus the net decrease of all classes is 614 or 0·4 per cent. All classes of dairy cattle show increases. Cows in milk are greater by 13,264 or 3·8 per cent, cows in calf by 20, and heifers in calf by 5172 or 8·5 per cent. Bulls show a decrease of 426 or 2·4 per cent. All classes of other cattle show increases. Those of two years old and above are more numerous by 9050 or 4·8 per cent, and those of one year old and under two by 17,940 or 6·0 per cent; the number of calves is greater by 15,354 or 5·9 per cent. The total number of cattle has thus increased by 60,374 or 4·9 per cent. The total number of sheep, 7,811,144, is 105,280 or 1·3 per cent below that of 1932. Breeding ewes are less by 56,894 or 1·7 per cent, and lambs by 23,769 or 0·7 per cent. Other sheep one year old and above have decreased by 23,610 or 2·5 per cent and rams by 1007 or 1·1 per cent. Pigs show an increase of 1703 or 1·0 per cent. The number of sows is greater by 2197 or 11·1 per cent and boars by 276 or 12·6 per cent, while other pigs are less by 770 or 0·5 per cent.

The acreage under rough grazings, 10,440,654 acres, is 72,476 acres more than last year: included in this figure is the estimated area of land in deer forests used or capable of being used for grazing, which in 1933 amounted to 1,068,489 acres. The figures for cattle and sheep in Scotland include 2468 cattle and 65,118 sheep grazing in deer forests on 4th June; of these, 1286 cattle and 43,554 sheep were also included in returns made by agricultural occupiers. The necessary adjustments have been made so that no duplication has taken place in the statement of totals for Scotland.

The poultry figures are as follows :—

Fowls over six months old	3,742,588
Fowls under six months old	4,351,659
Ducks over „ „ „	160,386
Ducks under „ „ „	101,967
Geese over „ „ „	7,498
Geese under „ „ „	19,901
Turkeys over „ „ „	18,323
Turkeys under six months old	111,725

The Agricultural Returns include statistics of acreage owned by occupiers, but these particulars are not included in the printed abstract. The total area of land under crops and grass returned as owned by occupiers of holdings in 1933 amounts to 1,512,726 acres, as compared with 1,482,088 acres in 1932, an increase of 30,638 acres. This area is 32·8 per cent of the whole area of land under crops and grass; in 1932 the proportion was 32·1 per cent.

The returns of labour employed on farms are summarised on pages 102-3.

Agricultural Conditions in 1933

THE year 1933 began with wet, stormy and, at times, rather severe weather that gave no hint whatever of the singularly dry and genial conditions of the spring, summer and autumn that were to come. During the second half of January and again at the end of February wintry conditions stopped ploughing, but the spells of frost undoubtedly benefited the soil and during this period farmers were afforded a good opportunity to empty dung courts and cart manure to the fields. Taken on the whole, the weather during March was remarkably dry, mild and sunny, and during the latter part of the month the conditions could scarcely have been more suitable for good husbandry. About the middle of April a short spell of frost and cold winds checked the growth of grass and the wheat braird. Throughout May and June, however, dry, bright conditions enabled farmers to make excellent progress with their seasonal work, while occasional local showers of mild rain promoted the growth of crops and maintained pastures in a fresh condition. Rather high temperatures and excessively dry weather prevailed during July over most parts of the country. In eastern districts the drought continued during August and the first three weeks of September, and harvest, which began exceptionally early, proceeded speedily under excellent conditions. In western districts wet and broken weather was general during most of August and a considerable proportion of the uncut grain was lodged, while some of the hay crop was damaged by the rain. Abnormally dry weather was experienced during the first three weeks of September

and fairly dry and mild conditions were repeated throughout the first three weeks of October, but moderately heavy showers of rain occurred during the last week or ten days of each of these months. The rain that fell greatly benefited pastures but was not sufficient to promote the normal growth of root crops and, for a time, turnips practically stopped growing. Occasional showers of rain fell during November and pastures regained a fresh appearance, while that part of the root crops still in the fields showed a slight increase in bulk. At the beginning of December farm work was exceptionally well forward for the time of the year.

During the autumn of 1932 the sowing of wheat was retarded by wet weather and the lateness of the harvest, some of the work being carried out when the conditions were not entirely favourable for seeding. The warm, dry weather of the summer months favoured the crop and, on the heavier class of land, the plants progressed exceptionally strongly. The ears filled well and the crop was healthy and ripened quickly. As very little of the grain was lodged, it was harvested with comparatively little labour and secured in very good condition. Wheat was probably the best of the cereal crops.

The sowing of barley progressed rapidly during April. The crop germinated well and throughout the period of growth the plants were almost entirely free from disease or insect pests. The bright, dry conditions that prevailed during most of June and July caused early ripening and, where grown on light soils, the straw was short. Most of the crop was secured in excellent condition and the grain is generally of good quality and colour, but of only moderate weight. Some of the grain ripened prematurely.

The weather conditions during March and the first half of April facilitated the seeding of oats. The crop brairded quickly and the sunshine and light showers of rain during May had a particularly good effect upon growth. The grain ripened about three weeks earlier than usual and reports indicated that in some districts, at all events, there had not been so satisfactory a grain harvest since 1868. The straw was short but, to a certain extent, this proved to be an advantage, as very little of the crop was lodged and cutting made rapid progress. Where grown on good, deep soil some excellent results were obtained but, taken on the whole, the yield was rather lighter than usual.

The weather conditions during May and June favoured the growth of beans and the plants quickly developed into a strong and healthy crop. After the blossoms had appeared the plants suffered somewhat from a lack of moisture and the stems were rather shorter than usual, but the crop podded well and the yield was generally well up to the average.

The planting of potatoes was practically finished by the end of May, the work having been carried out everywhere under the most favourable soil and weather conditions. Early varieties were

slightly affected with blight but they generally yielded an average crop of good quality. During July and August in the drier eastern counties the main crop suffered from a lack of moisture and, although the rain that fell towards the end of September helped to swell out the tubers, a larger proportion than usual was of seed size. The warm, cloudy weather and moister conditions that were general for a short time at the end of the growing season caused blight to make its appearance in that part of the crop that had not been lifted, and some of the tubers became diseased. Most of the crop was lifted and pitted under almost ideal conditions.

The sowing of turnips and swedes went forward with little or no hindrance, but growth was slow and re-sowing was necessary to a greater or lesser extent in many districts, while at the beginning of July in the drier eastern counties on light soils the crop was failing from want of moisture. During August and September swedes developed moderately well, but in eastern districts turnips grew very little and the crop became badly affected with mildew. At the beginning of October the general prospects of the crop were extremely bad; mildew had spread to practically every part of the country, while several complaints were received that finger-and-toe was prevalent and in many fields the turnips were rotting. Rain that fell subsequently freshened the crop, swelled the roots and washed off the mildew. The keeping quality of the crop is, however, very uncertain.

In some areas the mangold crop was affected by the drought, but, speaking generally, the roots suffered comparatively little from the dry conditions and, indeed, the exceptionally long duration of sunshine and relatively high temperatures appeared to benefit their growth.

The dry, bright season undoubtedly benefited sugar beet, which grew very satisfactorily and was the best and healthiest of the root crops. The roots were sound and of good shape and weight, while the sugar content was high. The weather conditions were almost ideal for lifting and most of the crop was despatched to the factory in a clean condition early in November.

Ryegrass and clover "seeds" suffered little, if any, injury from the lodging of the grain crops in the year 1932, but in some cases during the last few months of the year growth was perceptibly retarded by the excessively wet condition of the soil. Spring growth was fairly satisfactory, particularly in western districts where the weather was softer, but during the early summer months the general absence of rain and the rather high temperatures caused both "seeds" and meadow grass to mature exceptionally early and the crop, in consequence, was lighter than usual. On many farms harvest was completed in record time; in most parts of the country the work proceeded without interruption and, as practically all of the crop was secured without a shower of rain, the quality of the hay is better than it has been for several years.

With an extraordinarily early harvest followed by several weeks of fine, open weather, farmers made remarkably good progress with autumn work. In some cases wheat was sown on farms where there is no record of the crop having been grown before. The seed germinated very quickly, and at the beginning of December the plants were growing strongly and looked particularly well.

For some milk producers the season was a difficult one; pastures were rather bare during the long dry summer and extra hand-feeding was necessary to maintain the milk yield at the usual level. The condition of dairy stock was, however, generally reported to be good. The weather conditions of the summer and autumn were more favourable for sheep stocks than for cattle. At the time of lambing shepherds experienced comparatively little trouble, the crop of lambs being fully up to the average and the casualties fewer than usual. Clipping was carried out in fine weather and the hoggs and ewes improved quickly without the fleece. Several complaints were received, however, that flocks were badly troubled by maggots, and at the end of July it was reported that in North-east Aberdeen old shepherds were of the opinion that this had been the worst season for maggots they had known.

Annual Estimates of the Produce of Crops

The following Statement regarding the Produce of Crops for 1933 was issued on 21st December.

Preliminary Statement showing the ESTIMATED TOTAL PRODUCE and YIELD PER ACRE of Wheat, Barley, Oats, Beans, Hay, Potatoes and Roots, in SCOTLAND in the Year 1933, with COMPARISONS for 1932, and the AVERAGE YIELD PER ACRE of the Ten Years 1923-32.

Crops		Estimated Total Produce		Acreage		Average Estimated Yield per Acre.			Average of the Ten Years 1923-1932
		1933	1932	1933	1932		1933	1932	
Wheat . .	*Tons* *Quarters*	93,000 417,000	60,000 270,000	78,386	52,072	*Cwt.* *Bushels*	23·7 42·6	23·0 41·5	21·2 38·8
Barley (including Bere)	*Tons* *Quarters*	57,000 298,000	66,000 342,000	59,808	68,868	*Cwt.* *Bushels*	19·1 39·8	19·3 39·7	17·9 37·3
Oats . . .	*Tons* *Quarters*	694,000 4,648,000	746,000 4,993,000	855,857	867,374	*Cwt.* *Bushels*	16·2 43·4	17·2 46·1	15·4 42·0
Beans . .	*Tons* *Quarters*	2,800 12,700	2,600 11,900	3,035	2,737	*Cwt.* *Bushels*	18·5 33·4	19·3 34·7	18·1 32·8
Hay from Rotation Grass .	*Tons*	623,000	659,000	391,497	397,116	*Cwt.*	31·8	33·2	33·0
Hay from Permanent Grass	*Tons*	162,000	154,000	127,701	120,534	*Cwt.*	25·4	25·6	26·7

Hay from Timothy Meadows	*Tons*	110,000	107,000	51,212	45,920	*Cwt.*	42·8	46·5	44·4
Potatoes . .	*Tons*	1,077,000	1,142,000	152,513	148,539	*Tons*	7·1	7·7	6·6
Turnips and Swedes . .	*Tons*	5,006,000	5,780,000	351,653	348,464	*Tons*	14·2	16·6	16·6
Mangolds . .	*Tons*	31,700	21,900	1,389	1,072	*Tons*	22·7	20·4	18·5

NOTE.—The outstanding feature of the returns is the large increase in the production of wheat, the total being 93,000 tons, which is 33,000 tons greater than that of 1932. The area under the crop is greater by over 26,000 acres, while the average yield per acre, 23·7 cwt., is 0·7 cwt. over last year's figure, and exceeds the decennial average by 2·5 cwt. Barley, with a total produce of 57,000 tons, shows a decrease of 9000 tons. The area harvested is less than that of 1932 by 9060 acres, while the yield per acre is below that of the preceding year by 0·2 cwt. but exceeds the average of the last ten years by 1·2 cwt. The total production of oats is shown as 694,000 tons, a decrease as compared with the previous year of 52,000 tons: the area harvested is less by 11,517 acres. The yield per acre, 16·2 cwt., is less than last year by 1·0 cwt., but is greater than the ten years' average by 0·8 cwt. The produce of beans, 2800 tons, is 200 tons greater than in 1932, the area under the crop, 3035 acres, shows an increase of 298 acres over that of the preceding year. The yield per acre, 18·5 cwt., is less than in 1932 by 0·8 cwt., but exceeds the decennial average by 0·4 cwt.

The total produce of hay of all kinds, 895,000 tons, is 25,000 tons below last year's total. Hay from rotation grass, with a production of 623,000 tons, is 36,000 tons less than in 1932. The area is smaller than in the preceding year by 5619 acres, while the yield per acre, 31·8 cwt., shows a diminution of 1·4 cwt. on the previous year's figure and is 1·2 cwt. below the ten years' average. Timothy meadows, with an average yield of 42·8 cwt., produced 110,000 tons or 3000 tons more than last year, while other meadows with an average yield of 25·4 cwt. produced 162,000 tons, an increase over 1932 of 8000 tons.

The total production of potatoes, 1,077,000 tons, is 65,000 below that of 1932. There is an increase of 3974 acres in the area under the crop, but a decrease of 0·6 ton in the yield per acre, which is 7·1 tons as compared with 7·7 tons in 1932, and 6·6 tons for the ten years' average. Turnips and swedes with a total produce of 5,006,000 tons, the lowest on record, show a decrease of 774,000 tons. The area is greater than in 1932 by 3189 acres, but the yield per acre, 14·2 tons, the lowest since 1918, is 2·4 tons less than that of the preceding year, which equalled the average of the last ten years. Mangolds, with an increased area of 317 acres, show a total production of 31,700 tons, which is greater than that of 1932 by 9800 tons. The yield per acre, 22·7 tons, the highest ever recorded, is 2·3 tons greater than in the previous year and exceeds the decennial average by 4·2 tons.

All the above crops, with the exceptions of wheat and mangolds, show a reduction in the yield per acre as compared with the yield in 1932.

SEED TESTING AND PLANT REGISTRATION STATION

PART I—SEED TESTING STATION

Report for the period from 1*st August* 1932 *till* 31*st July* 1933

THE principal function of the Department's Seed Testing Station is to supply to vendors of seeds reports conveying information regarding samples submitted which will enable these vendors to make the statutory declaration of quality required by (*a*) the Seeds Act and Regulations, and (*b*) the Regulations governing import of seeds into other countries in respect of the seed stocks represented by the samples.

For this major purpose analyses, chiefly for the purpose of ascertaining the percentage of purity and germination, to the average number of 7400 of an average total of 8500, are made annually. During the period to which this report refers the number was 6915, out of a total of 8208.

Samples to the number of 320, taken by the Department's inspectors on the premises of 248 merchants for the purpose of ascertaining if the provisions of the Seeds Act and Regulations were being generally carried out, were also the subjects of test. This control has indicated that the Seed Trade in Scotland carries out loyally the obligations imposed by the Act. Approximately four per cent of the declarations given in respect of officially drawn samples differed sensibly from the findings of the Seed Testing Station, most of them only to a minor degree. Flagrant evasions of the provisions of the Act are of uncommon occurrence, and only in one instance in the season 1932-3 has the Department found it necessary to resort to proceedings against any person concerned with the sale of seeds.

Farmers in general appear to consider that their interests are adequately protected by the functioning of the Act and by the control exercised over sellers by the Department, as very few take advantage of the cheap service available to have deliveries of their spring sowings of seeds tested at the Station. Farmers' samples totalled 123, and 139 were tested for farmers' societies. One batch of samples was submitted by a large co-operative agricultural society for the advice of the Station as to the best source of purchase.

Certain seed merchants are licensed by the Department to make tests of their stocks on their own premises. A regular system of inspection of these premises is maintained by the Department, as a result of which check tests were carried out on 292 samples which had been the subjects of tests at these private seed testing stations.

Of the remaining 419 samples tested, 313 represented the Department's own actual or prospective purchases, while 106 were tested for miscellaneous purposes, some for the particular information of the Station, some for the information of agricultural colleges and other state-aided institutions, others as part of a co-operative effort to maintain uniformity between seed testing stations in this country and abroad.

For the purpose of internal trade it is important that there should be a high degree of uniformity of technique in the English, Scottish and Irish Seed Testing Stations, for which reason interchange of samples is frequent. The maintenance of uniformity is almost as necessary to international trade. This is attained through the medium of the International Seed Testing Association. A special common form of international report is now issued, on request, by all European Seed Testing Stations. Uniformity of testing method is checked annually by the circulation of test samples to stations participating in the activities of the Association. The operations of this Association since 1921 have had the effect of ensuring a high degree of uniformity in methods of seed testing throughout the world.

The seed harvest of 1932 in Great Britain and Ireland was an excellent one. In consequence there was abundance of home grown seed of good quality of cereals, ryegrasses, timothy, red clover, wild white clover, turnip and swede.

Statistical Results, 1932-3

GRASSES

Variety.	Number of samples	Purity			Germination			Percentage number of samples			Prescribed percentage standard of germination
		Highest	Lowest	Average	Highest	Lowest	Average	containing 2% or more of injurious weed seeds	below prescribed standard of purity (98%)	below prescribed standard of germination	
		%	%	%	%	%	%				
Perennial Ryegrass .	856	99·8	69·7	98·3	98	20	89	3·6	18·1	17·9	85
Italian Ryegrass .	475	99·9	63·6	98·9	99	29	91	2·7	6·4	6·3	80
Mixture—Perennial and Italian Ryegrass .	41	99·5	70·3	97·9	94	27	86	5·4	8·1	15·0	82
Meadow Fescue. .	93	99·7	92·0	98·6	99	27	94	..	..	..	..
Cocksfoot . .	534	98·8	67·6	91·4	99	28	93	..	..	..	..
Timothy . . .	306	99·9	77·2	98·4	99	3	94	..	..	..	..
Dogstail . . .	93	99·7	99·0	96·9	99	33	86	..	..	..	..
Tall Oatgrass . .	23	95·4	88·3	92·4	94	82	89	..	..	..	..
Meadow Foxtail .	12	76·9	7·2	61·3	83	54	70	..	..	..	..
Rough Stalked Meadow Grass .	99	99·3	89·3	94·3	98	76	92	..	..	..	..
Smooth Stalked Meadow Grass .	22	98·2	80·6	89·5	94	60	84	..	...	..	..
Hard Fescue . .	44	98·8	81·9	93·0	93	76	88	..	..	..	..
Tall Fescue . .	30	98·7	83 5	93·9	98	31	87	..	..	..	..
Agrostis . . .	25	99·9	87·7	97·9	98	23	86	..	..	..	..
Fine-leaved Fescue .	7	96·5	7[illegible]·6	83·0	84	58	70	..	..	..	..
Chewings Fescue .	25	98·9	96·5	98·2	90	39	70	..	..	..	..
Red Fescue . .	10	99·2	95·6	97·8	97	62	84	..	..	..	..
Poa nemoralis . .	6	90·8	80·6	85·3	85	63	77	..	..	..	..
Holcus . . .	11	95·8	39·3	65·1	96	60	83	..	..	..	..
Mixed Poas . .	6	78·6	48·6	67·8	97	89	75	80·0	..	..	..

Perennial ryegrass of exceptionally good quality was available at a very low price. The average purity of the samples was one per cent higher and the germination four per cent higher than the averages of the past eleven seasons.

A feature of the supply of perennial ryegrass is the increase, year by year, of the number of samples described as Evergreen, Kent Evergreen and Ayrshire-grown Evergreen perennial ryegrass, the last-named being a reputed derivative from seed of Kent Evergreen grown in Ayrshire.

While the seed of genuine Kent Evergreen, which is for the most part harvested with wild white clover and is a by-product of the harvest of that crop, is small and short, that of the reputedly Ayrshire-grown stocks is indistinguishable in bulk from ordinary Ayrshire perennial ryegrass.

Italian ryegrass was also above average quality. Both Irish and Danish seed were available in 1933. The quality of French seed was much below normal, however, and there were few imports.

The gradual disappearance from the market of natural mixture of Italian and perennial ryegrass is another feature of the ryegrass supply. It would appear that a considerable number of parcels of this crop is bulked with Italian ryegrass, the whole bulk being sold as Italian ryegrass.

The increasing inclusion, in samples of Italian ryegrass, of unawned seed, much of which can be identified as perennial ryegrass, helps to support this suspicion.

Cocksfoot samples represented stocks Danish in origin to the extent of two-thirds of the total. The remainder represented equally Late-flowering leafy stocks from Sweden (Swedish Late-flowering) and New Zealand (Akoroa).

Statistical Results, 1932-3

CLOVERS

Variety	Number of samples	Purity: Highest	Purity: Lowest	Purity: Average	Germination: Highest	Germination: Lowest	Germination: Average	Percentage Number of samples containing: 1 % or more of injurious weed seeds	Percentage Number of samples containing: 2 % or more of Suckling Clover
Red Clover	751	99·8	81·6	98·1	98+1	45+ 1	88+5	6·	..
White Clover	305	99·8	82·1	97·4	99+0	64+34	90+6	4·	2·6
Wild White Clover	370	99·8	75·9	97·8	98+1	41+30	86+8	3·	1·8
Alsyke Clover	197	99·6	88·9	97·0	99+0	72+23	92+3	5·	..
Alsyke and White Clover	18	99·6	94·0	97·9	98+1	68+11	87+6	..	..
Trefoil	65	99·9	97·5	99·3	89+5	62+11	82+7	..	..
Kidney Vetch	26	96·8	83·9	92·1	92+1	66+14	84+8	..	..
Lucerne	2	..	..	98·6	..	..	87+6	..	..

Red clover—Late-flowering red clover.—English seed of fine

quality was available in plenty. Imports of seed from North and South America were on this account restricted.

The number of samples received seems to indicate that the use of Swedish Late-flowering red clover and of Montgomery red clover is on the increase.

Wild white clover seed was of fine colour and of good quality. From a particular inspection of the seed of the samples submitted it was estimated that at least 97 per cent of the samples represented stocks of the genuine plant.

Certification of Wild White Clover Seed Stocks.

A scheme for the certification of wild white clover seed stocks is now in operation in England. Buyers of the certified stocks are assured of a supply of genuine wild white clover seed. Moreover, by ascertaining the certified number of their purchase and by submitting a small sample to the Department's Station for comparison with the type sample deposited there, they can make this assurance absolute.

STATISTICAL RESULTS, 1932-3

CEREALS

Variety	Number of samples	Purity			Germination			Prescribed percentage standard of germination	Percentage number of samples below prescribed standard
		Highest	Lowest	Average	Highest	Lowest	Average		
Oats . .	1494	100	92·1	99·8	100	46	97	85	1·5
Wheat . .	625	99·9	85·5	99·0	100	25	95	90	10·4
Barley . .	88	100	96·9	99·7	100	73	98	90	2·3
Rye . .	21	99·8	94·6	98·6	99	22	83	80	19·0

Cereals.—There was in 1932-3 a marked diminution (25 per cent) in the number of samples of oats and barley submitted for test and a compensating increase in the number of wheat samples. This undoubtedly reflects the influence of the official subsidy provided for the growing of wheat and of the poor market for oats and barley.

Avena strigosa (*Bristle-pointed Oat*).—The occurrence of this wild oat appears to be becoming progressively more frequent, especially in Black Oats. It was noted in approximately 25 per cent of the samples and in one instance to the extent of 6·4 per cent of the sample.

Ear cockles in wheat were noted in 7 per cent, and *Bunt* in 2·4 per cent of the samples.

Statistical Results, 1932-3

ROOTS AND VEGETABLES

Variety	Number of samples	Average percentage of		Prescribed standard percentage of		Percentage of samples below standard of	
		Purity	Germination	Purity	Germination	Purity	Germination
Turnip	366	99·3	91	0·8	5·8	97	80
Swede	278	99·3	89	0·4	8·3	97	80
Rape	35	99·3	95	..	..	97	80
Cabbage and Savoy	51	99·5	86	..	3·9	97	70
Kale and Borecole	34	99·3	87	8·8	5·9	97	70
Brussels Sprouts	15	98·7	90	13·3	..	97	70
Broccoli	10	99·4	82	..	..	97	60
Cauliflower	27	99·5	81	3·7	..	97	60
Carrot	94	95·3	69	1·1	3·4	90	50
Parsnip	16	97·2	76	43·8	12·5	97	45
Beet	45	98·2	73 clusters	19·5	4·4	97	50 clusters
Mangel	48	98·6	73 clusters	6·7	12·5	97	60 clusters
Peas	92	98·2	87	23·9	13·0	97	70
Beans	54	99·2	93	7·4	7·4	97	75
Vetches	52	98·6	96	3·8	7·7	97	90
Onion	86	99·7	75	..	15·1	97	60
Kohl Rabi	2	99·2	81	..	..	97	70
Leek	36	99·1	73	..	..	..	..
Lettuce	11	99·4	91	..	..	..	..
Radish	7	97·7	85	..	..	..	..
Mustard	3	99·8	91	..	..	..	..
Burnet	2	81·2	144 shoots	..	..	..	..
Parsley	5	96·7	64	..	..	..	..
Chicory	14	91·4	83	..	..	..	..
Ribgrass	18	90·6	84	..	..	..	..
Yarrow	5	87·0	87	..	..	..	..
Spinach	3	99·4	32	..	..	..	..
Brassica sp.	61	99·3	84	..	..	..	..

Part II—PLANT REGISTRATION STATION

Registration of New Varieties of the Potato

Potato Synonym Committee

The main duty of the Potato Synonym Committee is to recommend the issue of certificates of registration in respect of varieties submitted for test.

First Year's Test, 1931, *and Second Year's Test*, 1932.

Of the five varieties which were recommended for further trial three varieties (including one reintroduced) were included in the 1932 Maturity and Yield Trial.

The Committee recommended these three for further trial :—

Variety	Name of Sender
135(10) . . .	Scottish Society for Research in Plant Breeding
Ochiltree (Gladstone)	M'Gill & Smith, Ltd.
H.326 . . .	Dobbie & Co., Ltd.

First Year's Test, 1932.

Thirty-three varieties were submitted for inclusion in the First Year's Test in 1932. As a result of the trials 25 were found to be distinct and free from Wart Disease and the Committee recommended the following 17 varieties for inclusion in the 1933 Yield and Maturity Trials.

Variety	Name of Sender
A 7/30 . . .	Dobbie & Co., Ltd.
A 9/30 . . .	,, ,,
A 10/30 . . .	,, ,,
155/7 . . .	D. Mackelvie
159/48 . . .	,,
176/23 . . .	,,
121(2) . . .	Scottish Society for Research in Plant Breeding
136(50) . . .	,, ,, ,,
138(69) . . .	,, ,, ,,
G.162 . . .	C. T. Spence
G.A.21 . . .	,,
L.108 . . .	,,
7268 . . .	M'Gill & Smith, Ltd.
4276 . . .	,, ,,
453 . . .	W. B. Pollock
772 . . .	,,
914 . . .	,,

Since the inception of the Committee in 1921, five varieties, namely, Arran Consul, Herald, Arran Banner, Arran Crest and Arran Pilot have been recommended for certification and have been registered.

Wart Disease Testing Station

Single Tuber Trials.

The number of seedlings under field test for the first time in 1932 was 673. A considerable number of these had already been subjected to the intensive test in the laboratory.

The following is a summary of the field results :—

Free from Wart Disease	592
Affected with Wart Disease . . .	87
Undetermined	57

Particular observations were made on the cropping performance of these seedlings. In 1932, 140 seedlings were selected for further observation. Of the 53 varieties submitted for Registration Test in 1933, 31 had undergone this preliminary trial.

Inter-Departmental Tests.

In accordance with the instructions of the Inter-departmental Committee for Wart Disease testing, new varieties under test by the National Institute for Agricultural Botany and the Ministry of Agriculture for Northern Ireland, at Ormskirk and Kilkeel respectively, were included in the Department's Wart Disease trials at Philipstoun for the purpose of confirming determinations made at the above-mentioned centres.

The number of varieties for this purpose was : —

	1932
From the National Institute of Agricultural Botany	15
From the Ministry of Agriculture for Northern Ireland	11

The number of varieties distributed by the stations to Ormskirk and Kilkeel for the same purpose in the spring of 1932 was 3.

Laboratory Wart Disease Tests, 1932-3

These tests were continued according to the intensive contact method, by which large numbers of potato varieties may be tested simultaneously. The degree to which the technique of this test has been perfected is such that negative results are hardly ever obtained. Tubers under test are sprouted at their rose ends to the extent of ½ mm. in moist sphagnum Each tuber is turned rose end up and a ring of vaseline is applied round the sprouts. A small piece of active wart is placed within the vaseline ring in contact with the sprouts. Water is applied, sufficient to make a film connecting inoculum and sprout. The purpose of the vaseline ring is to prevent the water from escaping down the side of the tuber. The inoculum is left in contact for 48 hours, after which the tuber is turned rose end downwards in the moist sphagnum. The tubers are placed in zinc trays with covers to exclude light and to conserve moisture. Results of infection are usually apparent in from five to eight days. Varieties which are definitely susceptible can be determined as such in as short a time as 12 days.

In order to have a plentiful supply of active infective material available for these tests it is necessary throughout the season to maintain a stock of developing Wart Disease. Stock is prepared

by the following method: Tubers are placed rose ends downwards in a layer of moist sphagnum impregnated with rotted wart. Warts appear in about four weeks.

Whilst the tests are in progress an overhead temperature of 16° C.–20° C. is maintained during the day.

The following is a statement of results of tests of seedling varieties submitted by breeders during season 1931-2:—

Number of single tuber samples	756
Number susceptible	116
Number of four tuber samples	98
Number susceptible	15

The term "susceptible" here connotes a degree of susceptibility where the parasite completes its life history in a sample and produces on the sample definite rugose warty tissue.

Inter-Departmental Check Varieties.

In accordance with a recommendation of the Inter-departmental Committee on Wart Disease testing, all varieties in their second year of field test for Wart Disease at the stations of the National Institute of Agricultural Botany (Ormskirk), Ministry of Agriculture for Northern Ireland (Kilkeel), and Department of Agriculture for Scotland (Philipstoun), were subjected to the intensive contact test for the purpose of establishing, in co-operation with the Ormskirk Station, the actual grade of immunity of each variety submitted to the three stations. The degrees of infection provisionally prescribed by the Committee for the purpose of this classification are:—

(*a*) No trace of infection by the Wart Disease organism during the test.
(*b*) Radial galls (incipient infections) present.
(*c*) Types of infection intermediate between (*b*) and (*d*) present.
(*d*) Definite warty tissue developed.

Varieties were graded in numbers as follows:—

Grade (*a*)	None
Grade (*b*)	24
Grade (*b*)-(*c*)	4
Grade (*c*)	16
Grade (*d*)	None

Registration Tests.

All varieties undergoing first year's trial at East Craigs and Philipstoun were submitted to laboratory test. The following is a statement of determinations according to grade of immunity:—

Grade (*a*)	None
Grade (*b*)	22
Grade (*b*)-(*c*)	2
Grade (*c*)	15
Grade (*d*)	15

Virus Diseases of the Potato

Investigations—Unit Selections—Building up Healthy Stocks[1]

A complete account of the work carried out under the Virus Diseases Scheme initiated by the Department in 1929 will be published in the April number of this *Journal*.

Analysis of Potato Stock Seed Samples

The Department issues "Stock Seed" Reports in respect of crops of potatoes which are found on inspection during the growing season to be 99·95 per cent pure and true to type, to contain no wildings, bolters, or leaf roll, not more than one plant with severe mosaic and twenty with mild mosaic (or none with severe mosaic and 25 with mild mosaic) per acre and not more than one per cent of blackleg at second inspection. No crop is rejected on account of faint mottling.

The area of stock seed crops in Scotland in 1932 was 1237 acres. Following established procedure, representative samples of stock seed crops were planted at East Craigs in 1933 for purposes of analysis, demonstration and establishment of strict uniformity amongst inspectors in the assessment of complete health of stocks. Samples of King Edward and Great Scot (931 acres) were excluded, previous experience having shown that a subsequent check on stock seed stocks of these varieties was unnecessary. The number of samples of stocks originally produced by building up and in the possession of the original growers was 29. Stocks derived from built-up stocks numbered 8.

Although mild mottling is necessarily ignored in field inspections it may nevertheless on occasion have some significance as indicating a phase of a mosaic disease. In the following analyses, therefore, plants which show mild mottling have been noted.

Analysis of Health of Stock Seed Samples in 1933

Number of samples and the varieties represented		Acreage represented	State of health
First Early—			
3	Arran Crest	$2\frac{3}{4}$	All healthy.
7	Arran Pilot	$5\frac{47}{100}$	2 samples healthy. 1 sample with 1 plant mild mottle and 1 plant mild mosaic. 2 samples with 1 plant and 2 plants respectively with mild mosaic. 2 samples with 1 plant and 3 plants respectively with mild mottle.
3	Arran Scout	$2\frac{1}{2}$	All samples with mild mottle throughout.
5	Ballydoon	$3\frac{1}{16}$	All healthy.

[1] A list of growers who have built up stock and stock seed for disposal can be had by application to the Secretary, Department of Agriculture for Scotland, York Buildings, Queen Street, Edinburgh.

Number of samples and the varieties represented		Acreage represented	State of health
2	Di Vernon . .	$\frac{5}{8}$	Both healthy.
7	Duke of York .	$5\frac{5}{8}$	2 samples healthy. 3 samples each with 1 plant mild mottle. 1 sample with 4 plants mild mottle and 1 plant mild mosaic. 1 sample with 11 plants mild mottle and 2 plants mild mosaic.
1	Epicure . .	2	Healthy.
1	Herald . .	$\frac{3}{8}$	Healthy.
1	May Queen . .	$\frac{1}{4}$	Healthy.
3	Sharpe's Express .	$4\frac{3}{4}$	All healthy.
1	Witchhill . .	$\frac{1}{4}$	Healthy.
Second Early—			
1	Arran Luxury .	$\frac{1}{4}$	Healthy.
1	Ben Lomond .	$\frac{3}{8}$	Healthy.
2	British Queen .	5	Both healthy.
5	Catriona . .	$2\frac{1}{4}$	1 sample healthy. 3 samples each with 1 plant mild mosaic. 1 sample with 2 plants mild mottle.
4	Cumnock . .	$1\frac{9}{10}$	3 samples healthy. 1 sample with 2 plants mild mottle.
Early Maincrop—			
2	Ally . . .	$3\frac{1}{2}$	1 sample with 1 plant mild mottle. 1 sample with 1 plant mild mottle and 1 plant mild mosaic.
6	Arran Banner .	$16\frac{11}{12}$	3 samples healthy. 1 sample with 1 plant leaf roll. 1 sample with 1 plant mild mottle. 1 sample with 3 plants mild mottle and 1 plant mild mosaic.
2	Doon Star . .	4	1 sample with 2 plants mild mottle and 6 plants mild mosaic. 1 sample with 2 plants mild mottle and 1 plant mild mosaic.
1	Gladstone . .	$\frac{1}{4}$	Healthy.
11	Majestic . .	$32\frac{27}{40}$	6 samples healthy. 3 samples with 1, 2 and 9 plants respectively with mild mottle. 1 sample with 5 plants mild mottle and 1 plant mild mosaic. 1 sample with 1 plant mild mottle and 1 plant mild mosaic.
1	Tinwald Perfection	$\frac{1}{4}$	Sample with 1 plant severe mosaic, remainder mottled.

Number of samples and the varieties represented		Acreage represented	State of health
Late Maincrop—			
2	Arran Cairn	$\frac{5}{8}$	Both healthy.
1	Arran Chief	$\frac{1}{4}$	Healthy.
7	Arran Consul	$15\frac{5}{6}$	6 samples healthy. 1 sample with 4 plants mild mottle.
2	Champion	$\frac{7}{24}$	1 sample healthy. 1 sample with 2 plants mild mottle.
1	Doon Pearl	$\frac{3}{4}$	Sample with 1 plant mild mottle.
5	Dunbar Cavalier	$8\frac{5}{8}$	3 samples healthy. 1 sample with 1 plant leaf roll. 1 sample with 6 plants leaf roll, 1 plant mild mottle and 1 plant mild mosaic.
1	Field Marshal	2	Healthy.
39	Golden Wonder	$153\frac{1}{4}$	31 samples healthy. 2 samples each with 1 plant severe mosaic. 1 sample with 3 plants severe mosaic. 2 samples with 2 plants and 1 plant respectively with mild mosaic. 1 sample with 2 plants mottled. 1 sample with 1 plant mild mottle. 1 sample with 5 plants leaf roll.
12	Kerr's Pink	$26\frac{1}{6}$	11 samples healthy. 1 sample with 1 plant mottled and 1 plant mild mosaic.
1	Up-to-date	1	Healthy.
141		$304\frac{3}{10}$	

1 sample each of Duke of York, Majestic, Kerr's Pink and Arran Crest had 1 plant affected with blackleg.

5 samples of Golden Wonder each had 1 plant with yellow mottling and 3 other samples of this variety had 2, 3 and 9 plants respectively with yellow mottling.

There was a number of single plants with yellow mottling throughout the samples but not to the extent of these found in Golden Wonder.

Registration Trials of Cereals

No variety of cereals submitted for registration was registered in 1932. The variety 644 (Scottish Society for Research in Plant Breeding) was carried forward in trial to 1933.

SCIENCE AND PRACTICE

The following extracts and summaries are supplied by members of the staffs of Scottish agricultural colleges and scientific institutions or are taken from recent bulletins of the International Institute of Agriculture. Full references to the original publications may be obtained on application to the Secretary, Department of Agriculture, York Buildings, Edinburgh.

CROPS AND SEEDS

Plant Breeding in the Soviet Union. *Imperial Bureau of Plant Genetics, Cambridge and Aberystwyth, November* 1933.—This work is a summary of the anniversary number of the new journal, *Plant Industry in U.S.S.R.*, and of Professor Vavilov's address at the Leningrad Congress, 1932, dealing with the Planning of Breeding and Genetic Investigations to be put in force during the second Five Year Plan.

A. The collection and systematic study of the economic plants of the world, unrivalled in completeness, has provided the initial material for breeding, and has furnished valuable information as to the centres of origin of the main cultivated plants, and has shown these centres as the source of the greatest number of ecotypes. The collection includes cereals, swedes, herbage and forage crops, cucumbers, potato, fruit trees, small bush fruits, medicinal plants and fibre plants.

B. The improvement of breeding methods, and certain of the achievements in the various groups are dealt with.

C. Research work in several allied subjects—technological analysis of plant varieties, laboratory test for technical quality of flax and hemp and methods employed, physiology and agrometeorology.

D. Organisation of research. The Institute of Plant Industry consists of four autonomous sections, and under these sections the following programme for the second Five Year Plan is to be undertaken, dealing with the plants mentioned.

Problems of Special Genetics.—Initial material for breeding and genetical investigation; immunity to disease; drought resistance; winter hardiness and cold resistance; vegetative period; chemical composition of plants; technological differences between varieties; varietal differences with regard to substrate; quantitative characters.

Problems of General Genetics.—Distant hybridisation; crossing geographical races; heterosis; phenomena of polyphloidy; problems of artificial mutation; permanent modifications; chimæras; inheritance of quantitative characters; sex in plants; floral biology in relation to breeding methods; theory of in-breeding; problems of the gene and questions of phenogenetics; problems of origin of cultivated plants.

An interesting bibliography of further references is added.

Psyllid Yellows of the Potato. *B. L. Richards and H. L. Blood, Utah Agricultural Experiment Station. Journal of Agricultural Research, Volume 46, No. 3, February* 1933.—This disease of the potato first came to the attention of plant pathologists in 1927. The disease may develop suddenly over a vast area in any one season, and is capable of extensive and frequently complete destruction in both the early and late potato crop.

The tomato psyllid (*Paratrioza cockerelli* Sulc.) has been found constantly associated with psyllid yellows of the potato, and experiments have shown that the disease is in some way introduced during the feeding process of nymphs of this insect.

The true nature of the infective principle injected into potato plants by tomato psyllid at present remains unknown. The virus theory of the disease is questioned, and available facts suggest the possible existence of some toxic substance which is produced during the feeding process of the psyllid nymphs.

Some Factors affecting the Palatability of Pasture Plants. *A. B. Beaumont, R. E. Stitt, and R. S. Snell. Journal of the American Society of Agronomy, Volume 25, No. 2, February* 1933.—In Europe workers with pasture plants have taken into consideration the question of palatability, but pasture grasses important in Europe are not widely grown in the United States.

The object of the experiment was to furnish further information as to the palatability of plant species commonly used for permanent and semi-permanent pastures in the North-eastern United States under uniform and differential fertiliser treatments.

Summary and Conclusions.—"A study has been made of some factors thought to affect the palatability of pasture grasses. Timothy, redtop, Kentucky blue-grass, and white clover have been grown under differential fertiliser treatments. In addition, English rye-grass, Italian rye-grass, timothy, redtop, meadow fescue, red fescue, yellow oat-grass, and Reed canary grass have been grown under uniform fertiliser conditions.

Milch cows were allowed to graze selectively over the plots, and samples of the crop were taken for chemical and physical examination. The results are summarised as follows:—

"1. Plant species were selected by milch cows in the following order: Experiment A, 1st, white clover; 2nd, timothy; 3rd, redtop; 4th, Kentucky blue-grass. Experiment B, 1st, timothy; 2nd, redtop; 3rd, Italian rye-grass; 4th, English rye-grass; 5th, yellow oat-grass; 6th, meadow fescue; 7th, red fescue; and 8th, Reed canary, the last two hardly touched.

"2. Stage of growth is a factor which affects palatability. The preceding order of choice prevailed when grass was 4 to 6 inches high. When it was 2 to 4 inches high little discrimation was shown.

"3. The first year after seeding practically no difference in palatability could be referred to difference in fertiliser application, but the second year grass which had received nitrogen and minerals was grazed more than that which had received only minerals or no fertiliser. Grass which received high nitrogen appeared to be slightly more palatable than that which received medium or low amounts.

"4. Toughness of grasses was determined by breaking or cutting the individual blades of grass. By this method red fescue and Kentucky blue-grass proved significantly tougher than timothy and redtop. The former were also less palatable than the latter; but Reed canary, one of the least palatable, was the least tough."

SOILS

The Action of Potash on Higher Plants. *Rippel, Behr and Meyer. Zeit. Pf. Dung. U. Bodenk*, 1933, *32*, 1/2, 95.—Reference is made to a previous set of pot experiments which showed the effect of increasing quantities of nitrogen on the growth of oats. A similar series with potash is now described, and the different effects of potash and nitrogen on growth are pointed out. Similar experiments with potash have also been conducted on potatoes.

Studies on Readily Soluble Phosphate in Soils: III. The Effect of Phosphate Treatment. *Lohse and Ruhnke. Soil Sci.*, 1933, *36*, 4, 303.—A technique is given for the determination of the ability of a soil to convert soluble phosphates. Extraction studies have been made on phosphate-treated soil samples, and the effects of basic materials and of fertiliser salts upon the solubility of various phosphates, when incorporated with soil, have been studied.

The Absorption and Movement of Sodium Chlorate when used as an Herbicide. *Loomis, Smith, Bissey and Arnold. Jour. Amer. Soc. Agron.*, 1933, *25*, 11, 724.—Sodium chlorate appears to penetrate readily all of the external surfaces of the plant with the possible exception of corky layers. Within the plant the movement of sodium chlorate is most rapid in the direction of the transpiration stream. In the experiments described sodium chlorate was found to persist in the soil in an apparently unchanged form for 2½ years. The relative importance of factors such as leaching and soil temperature in the removal of sodium chlorate from the soil is discussed.

Sand and Water Culture Experiments on the Effect of the Copper Ion. *Scharrer and Schropp. Zeit. Pf. Dung. U. Bodenk.*, 1933, *32*, 3/4, 184.—An account is given of experiments on the effects of copper, in the form of copper sulphate of various concentrations, on wheat, rye, barley, oats, maize and peas. In the experiments with maize the effect of increasing the calcium concentration in counteracting toxicity from copper has been studied.

DAIRYING

Bitter Milk. *Bailey. Milk Plant Monthly*, 1933, *22* (9), 31-32.—A bitter astringent flavour may often be detected in raw milk, in cream and in the butter made from such materials. This defect is due to the activity of an enzyme called lipase, which is often present in the milk of old cows. By heating the fresh milk to 130° F. and holding for 30 minutes, the lipase is rendered inactive, and the milk rendered suitable for marketing or manufacturing purposes.

Loss of Vitality in Dairy Starters. *Whitehead and Wards. N.Z. Jour. Agric.*, 1933, *47* (4), 218.—The authors investigated a case of sudden failure of a starter used in factory cheese-making. This starter, originally obtained from the New Zealand Dairy Research Institute and propagated daily in the starter cans of the factory, worked satisfactorily for several months when it suddenly "petered out." Repeat cultures of the same starter supplied by the Institute also failed after two or three propagations under practical conditions. When, however, a mother culture of this starter was grown in small conical

flasks and used to inoculate the starter milk in bulk in the creamery cans, the starter worked satisfactorily for a time, whereas, when the inoculation was made from bulk to bulk in the cans, the starter failed entirely after one or two propagations. The authors claim that the mother culture method, in which the milk of inoculation is pasteurised, cooled and injected with as little agitation as possible in narrow-necked flasks, is of some value in maintaining the vigour of starters, especially with certain classes of milk.

Butter Manufacture. *Hesselberg. Svenska Mejeritidningen, 22* (49), 407.—In an attempt to improve the flavour, texture and keeping properties of butter, the author obtained a considerable degree of success by adding starter to the granular butter after it had been worked in the usual way with water. The method used was briefly as follows: The fresh cream is chilled overnight and churned next day to normal-sized grains. The buttermilk is run off, the granular butter washed twice with water, the wash water completely drained off, and starter equal in amount of 20 to 25 per cent. of the quantity of butter in the churn added. The churn is given several slow turns, then brought to rest for about one minute. This process is repeated and continued for about 30 minutes. The butter is then worked to incorporate the starter and to express the moisture. Drain off excess of starter and add salt as required.

ANIMAL BREEDING

Cattle

Inbreeding in Cattle. *T. E. Woodward and R. R. Graves.* 1933. *U.S. Dept. Agric. Tech. Bull., No.* 339.—Deliberate experiments into the hereditary constitution of cattle are few and far between. They could indeed be almost numbered on the fingers of two hands. Those which have been brought to anything like a conclusion are even fewer. The present experiment, designed to study the results of inbreeding in Guernseys and Holstein Friesians, was commenced in 1912 at the United States Dairy Experiment Station at Beltsville, Maryland.

The originators of this experiment asked themselves this question: "Can a good dairy herd be bred up from an ordinary one by the use of only one good bull?"

In 1912 16 cows of mixed breeding were purchased. They were of only average production and showed traces of Shorthorn, Angus and Jersey breeding. A Guernsey bull was purchased and mated to them; he was again mated to his own daughters out of these cows and then to his grand-daughters, and finally his sons and grandsons were mated to the uncertain progeny.

A number of deformed calves resulted from this source of inbreeding. They were all of the type known as the "bull-dog calf," and the evidence available indicates that this harmful character was carried by the Guernsey bull, and the results closely agree with those obtained by Professor Crew at the Institute of Animal Genetics.

As regards the production of milk and butterfat, the yields of the first generation daughters (outbred) were about the same as their dams, but the butterfat yield was higher by some 20 lb. The inbred grand daughters (which were also daughters) produced slightly less milk than their dams, but gave considerably more butterfat. From this we can conclude that the bull employed did not possess inherent capacity of raising the total yield of milk, but that he had, to a minor degree, the hereditary constitution for higher butterfat than the cows to which he was originally mated.

In the year 1913 the authorities realised that the results of such an experiment would depend largely upon the individuality of the bull used. Accordingly they purchased a Friesian bull which they used on the same foundation cows as those used for the Guernsey bull.

Inbreeding did not adversely affect the readiness with which the cows conceived. From 1926-31 89 highly inbred calves were born and there was no unusual occurrence of abnormality. In fact more pregnancies terminated normally than was the case in the outbred herd which was maintained at the same place, at the same time, and under the same conditions.

During the 20 years of this inbreeding experiment, only one deformed calf was born, and this deformity was not the same as that found in the inbred Guernseys. At first the birth weight of the calves showed a tendency to rise from 82 lb. with the first (outbred) generation (21 calves) to 103 lb. (18 calves) with the inbred generation by a son of the original bull. Much the same holds good as regards the growth rate of the inbred animals, but as regards size of the cows at maturity there is a difference. As inbreeding has become more intense there has been a definite trend in the direction of heavier weight at maturity, and this has not been accompanied by any signs of a loss of vigour. Only one of the inbred cows has been a delicate feeder.

The foundation cows had a yield of 1163 gallons. The first generation daughters (outbred) gave 1555 gallons with an increase of 70 lb. in butterfat yield. A subsequent generation has given 1823 gallons with an increase on the yield of the foundation cows of nearly 100 lb. of butterfat.

In this experiment a bull that proved to possess an inheritance for a high level of milk production has been mated to ordinary grade cows, and has brought about a big increase in production, especially in the first generation (outbred) daughters. Subsequent improvement through inbreeding was slow. The writers are of opinion that the hereditary constitution of a bull influences production more than the system of breeding.

Are High Records Harmful to a Cow's Progeny? *L. Copeland.* 1932. *Jersey Bulletin, Volume* 51, 223-41.—It is the belief of some breeders that a high record of milk production not only ruins the majority of the dairy cows completing such records but also impairs their transmitting abilities, with the result that their daughters and sons born after they have completed a high record are definitely inferior to those which were born before the high record was made.

Mr Copeland has studied this question with the material at his disposal in the offices of the American Jersey breed. He selected 113 medal of merit Jersey bulls whose dams have completed a record of over 600 lb. of fat. Fifty-seven of these were born after their dams had completed the record, while 56 were born before they had finished a record higher than 600 lb.

Similarly as regards the daughters, the basal line for their dams' production was taken as 700 gallons. For these it was found that the average production of their daughters born before the dam had completed this record was 651 lb. of butterfat, as compared with an average production of the daughters born after the dam had completed her record of 652 lb. This and other data indicate strongly that the making of a high record has no influence whatsoever on a cow's transmitting ability. While "forced feeding" may be harmful to the cow herself, such harmful effects are not transmitted to the progeny. It seems unwarranted to draw any other conclusions from these data, and these conclusions are consistent with modern genetic knowledge.

Cattle Production in France. *P. Dechambre.* 1933. *Rev. Zootech.*, 1933, 269-89. —The cattle population of France is over 15,000,000. Work cattle are tending to be replaced by horses, especially as early maturity is being developed in the breeds. Regulation against the indiscriminate use of bulls is portended, and during recent years the ratio of the number of bulls to cows has widened considerably. Three-quarters of the cows of the country are of the dairy breeds, and the milk industry is capable of much further development. The author presses for more intelligent utilisation of breeds adapted to certain environments. The illustrations are of individuals of French cattle breeds.

Goats

The Swiss Saanen Goat. *A. Kiesling.* 1933. *Z. Züchtg., B., Volume* 27, 113-36. —The Saanen breed originates from the Berner Oberland, where it has for a long time been selected for high milk production. While the Saanen is bred pure, inbreeding is prohibited. Females breed at 6 to 8 months of age, and it is then recommended to miss a year and to breed again in the third year, since in this year the best milkers are produced. An old male will serve about 80 females. The breeding season is in autumn, predominantly from October to November; gestation lasts 154 days. Twins are usual, triplets rarer. Lactation lasts 8 to 10 months, and it is often difficult to make an animal go dry.

Sterility of the males is frequent, but this is not common to the breed alone, but to the goat in general.

Horses

The Arab Thoroughbred. *H. Seydel.* 1933. *Arch. Tierer. Tierz., Volume* 9, 50-87. —Amongst Arab horses there exist different distinctive types, and there are in addition a multitude of other Oriental strains such as the Turkmenian, Karabagh, Persian, etc., which are also often included in the term "Arab." The true Arab is the Keheilan strain which has been bred pure since before the time of Mohammed. At the present day Arabia possesses little over 1000 animals of this type. It differs from other Arab and Oriental strains in a number of characters of which a list is given, particularly in the blue-black colour of the skin which has given rise to its name. The marked modificaton of the head is ascribed to the development of the brain in consequence of a constant association with man. Similarly the type of conformation is probably an adaptation to its mode of life. The length of neck, withers and croup and the depth of the trunk in the region of the shoulder, chest and hind-quarters are characters desired in a riding horse, and Keheilan is used exclusively as such. It never trots, and this would account for the long, obliquely situated shoulder. Rigorous conditions under which the horse has to live ensure the action of natural selection; over 50 per cent. of all foals die during the first year of life.

Among famous imported stallions and mares very few were Keheilan. Of the three

founders of the English thoroughbred Darley is the only one; Godolphin was a Barbary and Byerley Turk was a Turkmenian. In Germany the influence of the Keheilan has been small. In fact the total number of them outside Arabia hardly amounts to 250.

Pigs

Results of Pig Testing in Poland. *K. Rozycki.* 1933. *Przeglad. hodowl, Volume* 7, 175-80.—Poland has now fallen into line with other countries on the Continent, and has established Pig Testing Stations on the lines so successfully employed in Denmark. As in Scandinavia, 4 pigs from each litter are fed on a standard ration up to about 200 lb. live-weight, when they are killed and classified from the point of view of their bacon quality. The results so far obtained show a lesser degree of uniformity in the Polish stock than that obtained in the Scandinavian results. This is not unexpected since the Scandinavian work, which has gone on for about 20 years, has exerted a profound effect upon the quality of the stock and materially assisted the uniformity of the native Danish stock. The writer states that the Polish pigs are less early maturing than those from other countries. These two faults require immediate attention, especially as the quality of the meat and the general type are, on the whole, pretty good.

Seedy Cut in Pigs. *A. Deakin.* 1932. *Proc. VI Intern. Cong. Genetics, Volume* 2. 41-42.—This investigation, which was conducted at the Dominion Experimental Farm at Ottawa, deals with the presence of black pigment particularly in the mammary glands of the pig. The writer states that the black pigment may be found when pigment is present in the skin, but that the reverse also occurs when black pigment is found in the mammary glands although none is present in the skin: this he reports as occurring in the Duroc Jerseys. The writer considers that the presence or absence of pigment in the glands of the black breeds depends upon the time of the appearance of pigment in the epidermis of the nipple and upon the potency of the outer cells of the skin to absorb the pigment, this latter point being correlated with the intensity of pigmentation and rapidity of cell division. The writer considers it doubtful whether it would be possible to raise a strain of black pigs which would be consistently 100 per cent. free from seedy cut. He further states that in red breeds the pigmented glands can be seen through the skin in the live piglings, and that accordingly it is easier to select against the trouble in these breeds.

Poultry

The Effect of Inbreeding and Crossing Inbred Lines of White Leghorns. *M. A. Jull.* 1933. *J. Hered., Volume* 24, 93-101.—For 3 years brother × sister matings have been made, and the fertility of the eggs was not materially affected. The hatchability, however, decreased, but the greatest decrease occurred in the first year of inbreeding. The vigour of the chicks at birth was not affected; the age in days at which laying commenced was increased under inbreeding. The rate of egg production as determined by the number of eggs laid in the first 50 days after laying commenced showed a certain decrease, and similarly the total first year egg production was lower.

When two separate strains of inbred White Leghorns were crossed with each other the fertility went down but the hatchability increased, while the vigour of the chicks was also better. The age in days at which laying commenced was decreased, and the rate of egg production on the whole increased, while the total first year egg production was increased considerably.

Sheep

Wool Characters in "Half-Breed" Sheep. *J. E. Nichols. Jour. Agric. Science, Volume* 23, 473-84.—The "half-bred," the product of the Border Leicester ram and the Cheviot ewe, is an important contributor to the fat stock industry by reason of the sale of wether lambs for feeding in lowland areas, and the use of "half-bred" ewes with Down rams for the production of cross-bred fat lambs.

In many flocks in the Border districts a second generation of the cross is raised by inter-mating half-bred rams and ewes. Some time ago the writer examined the claims frequently made that the "half-bred breeds true." In a previous paper he has discussed the variation and segregation which occurred in the first and second generation flocks. In noting the real evidence of segregation in the second generation the writer then employed only the obvious external differences of the fleece.

In this paper the figures are given from detailed analyses of a series of wool samples taken from selected sheep. The wool studied represents approximately 12 months' growth in all the sheep, though the animals were of different ages. For comparison, data from a number of similar samples from Border Leicester ewes and from a ram-breeding flock were also included. The individuals for sampling were selected with the aid of the shepherds except in the case of the rams, where all those used were sampled. The

parental types of wool did not overlap. The wool of the Border Leciesters was greater in length than that of the Cheviots. The Border Leicesters studied were more uniform than the Cheviots, while the latter were more regular in fibre length.

As regards the first hybrid generation, the fibre lengths were for the most part intermediate between the parental types. The range of fineness was, however, greater than that of the Border Leicester ewes, but not so wide as that of the parental Cheviot samples.

Among the 83 ewes of the second generation of "half-bred" × "half-bred" the analyses show a wider range of mean fibre lengths, the range of fineness was greater, and the range of mean fibre volume overlapped both the Border Leicester and the Cheviot shoulder series.

The writer concludes that evidence of blending inheritance is not manifest in the results, which support the interpretation of multiple factors as responsible for the expression of the wool characters of length and fineness.

Sheep Blowfly in Australia. *R. J. Tillyard and H. R. Seddon.* 1933. *N.S. Wales Dept. Agric. Sci., Bull.* 40, 136.—Susceptibility to fly is due, firstly, to inherent characters in the sheep such as conformation and wool condition, by which certain parts of the body are predisposed to strike. Secondly, there are variable factors such as moisture, skin exudation and bacterial activity. For the most common type, conformation is most important as a predisposing factor, while for body strike the type of wool appears to be the determining factor. Breeding results show that progeny of apparently resistent parents are less frequently struck than those of proved susceptible parents.

Artificial Insemination in Sheep. *N. A. Kuznetzova.* 1932. *Probl. Zhivotn., No.* 5/6, 86-90. This report deals with 32,000 ewes and 60 rams. The average percentage of fertilisation was practically 80 per cent. which is higher than by normal mating. Two specially selected rams inseminated respectively 2733 and 1403 ewes during the mating season, with over 70 per cent. success.

ANIMAL NUTRITION

Feeding Experiments with Carcase Meal, Meat Meal, Meat and Bone Meal and Herring Meal of Low Fat Content. Fütterungsversuche mit Tierkörpermehl, Fleischfuttermehl, Fleischknochenmehl und fettarmem Heringsmehl. *W. Kleberger and V. Horn. Ztschr. f. Zuchtung, B.*, 1932, *26*, 103-112. (*Agric. Chem. Inst. L.-U., Giessen.*)—Two series of experiments were carried out with the above substances as protein supplements. The results were in agreement and showed that meat and bone meal gave the best results, with herring meal (low fat) almost equal. Carcase meal and meat meal followed. Utilisation and slaughter results were also best in the same two groups. The supplements with the highest content of calcium phosphate did best.

Feeding Test with Tapioca Meal on Milk Cows. Voederproef met Tapiocameel bij melkee. *E. Brouwer. Vereeniging tot Exploitatie eener Proefzuivelboerderij te Hoorn,* 1932, *Ann. Rep.* 1932, 79-111.—Records are given of feeding trials comparing maize meal with tapioca meal (S.E. 76, protein about 1·3 per cent.) plus earthnut meal to balance protein content. General results were satisfactory. Butter from the tapioca group was somewhat firmer. Vitamin content of tapioca meal is discussed.

Fish Meal *v.* Cotton-seed Meal as a Feed for Dairy Cows. *L. W. Ingham. Univ. Maryland Agric. Exp. Stat., Bull. No.* 342, *December* 1932 (*Coll. Park, Maryland.*)—Two groups of 6 cows and the double reversal method were used. The results indicated that there was no difference between the two meals as a source of protein in the rations of dairy cows. Costs would be the deciding factor. No bad flavour or odour was detected in milk when fish meal constituted about 13 per cent. of the production ration.

Wheat as a Fattening Feed for Cattle. *A. D. Weber and W. E. Connell. Agric. Exp. Stat., Kansas State Coll. Agric. and Appl. Sci., Bull. No.* 261, *November* 1932. (*Manhattan, Kansas.*)—Coarsely ground wheat and maize were compared in two series of groups of yearling cattle. In the first series the roughage consisted of silage and alfalfa hay, and in the second of alfalfa hay alone; cotton-seed meal was fed in addition to all groups. Ground wheat alone was less palatable than ground maize or mixtures of ground wheat and ground maize 2:1 or 1:2, and resulted in lower food consumption and poorer progress. Mixtures of wheat and maize 2:1 or 1:2 were as economical and yielded as good carcases as maize alone.

Influence of Iodine Feeding on the Development of Ewes and Lambs and on the Yield and Quality of Wool. *E. Véghelyi. Mezogaz. Kutatások*, 1931, *4*, 349.—Rations supplemented with 2 per cent. of calcium carbonate containing 0·15 per cent. potassium iodide produced greater live-weight increases in ewes and lambs and also raised the yield

and content of wool. The quality of the wool was not affected. The yield and content of the ewes' milk were increased.

Feeding Experiments on Pigs with Different Residues of Animal Origin. Ergebnisse von Fütterungsversuchen mit verschiedenen Abfallstoffen tierischer Herkunft an Schweinen. *Ph. Malkomesius. Ztschr. f. Züchtung. B.*, 1932, *26*, 79-102. (*Agric. Res. Stat., Rostock i. M.*)—Under the experimental conditions, all animal by-products, with the exception of whale meal, gave better live-weight gains in pig feeding than did plant protein sources, dried yeast, soya-bean meal, earthnut meal. Herring meal and whale meal had some unfavourable effect on carcase quality. Costs and feed utilisation were best with herring meal and meat meal. Doses of about 100 g. calcium phosphate per head per day appeared to be well tolerated.

Use of Swedes in Pig Fattening. Ein Beitrag zur zweckmässigen Verwertung der Steckrüben in der Schweinemast. *Dr Wilkens. Ztschr. f. Schweinezucht*, 1933, *40*, 404-05. (*Pig Breeding Stat., Ebstorf.*)—Thirty-eight pigs were divided into two groups. Both groups were fed the same basal ration of 10 per cent. barley, 40 per cent. rye, 20 per cent. oats, 10 per cent. herring meal, 12 per cent. soya meal and 8 per cent. blood meal, at the rate of 1 kg. per pig daily. The following foods were fed to appetite: Group I, $\frac{3}{4}$ steamed potatoes + $\frac{1}{4}$ raw, chopped swedes; Group II, steamed potatoes. The results showed that the rates of production of the two groups were approximately the same. Taking the food value of steamed potatoes as 100, the food value of the raw chopped swedes was found to be 35.

The Bran and Dried Milk Ration. Neue Beitrage zur Kleie-Trockenmilchfrage. *R. Fangauf, K. Müller and E. Kallmann. Arch. f. Geflügelk*, 1932, *6*, 289-305. (*Poultry Res. Inst., Kiel-Steenbek.*)—On the basis of feeding experiments it is stated that the Sweers ration of 72 per cent. wheat bran and 28 per cent. dried buttermilk as mash and 65 g. wheat as grain, which is too expensive for use by poultry keepers, can be altered so as to reduce the cost. The dried buttermilk can be reduced by 28 to 30 per cent. and instead of wheat, a mixture of cheap grains such as maize, oats, barley, rice and dari can be used. Further, the dried buttermilk can be replaced by dried skimmed milk or dried whey. A mixture of 25 per cent. dried skimmed milk and 75 per cent. bran, or 15 per cent. dried whey, and 85 per cent. bran is recommended.

Protein Levels in Battery Brooding Chicks. *A. E. Tepper, T. B. Charles and F. D. Reed. Agric. Exp. Stat., Univ. New Hampshire Circular, No. 40, March* 1933. (*Durham, N.H.*).—When the protein level for battery brooding chicks was increased from 15 to 20 per cent. it was found that for each increase of 1 per cent. of protein there was a definite increase in weight and efficiency of food consumption. Birds on the higher percentage matured more quickly, and produced larger eggs at the commencement of laying. There was no significant difference in the groups, however, four months later.

Fattening Cockerels on Potatoes. Beiträge zur Junghähnchenmast mit Kartoffeln. *W. Stahl and Fr. Haring. Arch. f. Geflügelk*, 1933, 7, 97-109. (*Res. Stat., Ruhlsdorf.*)—Extensive experiments in fattening cockerels showed that feeding sugar and sugar beet slices (24 per cent.) gave good results. Potato flakes, with an adequate protein supplement, may be used as chief component in a ration. Potato silage and steamed potatoes may also be used, so long as the protein ratio is adjusted.

Potato Flakes as a Substitute for Maize Meal for Laying Hens. Kartoffelflocken als Ersatz für Maisschrot bei Legehühnern. *R. Fangauf and R. Deditius. Arch. f. Geflügelk*, 1932, *6*, 372-77. (*Poultry Res. Stat., Kiel-Steenbek.*)—Potato flakes to the extent of 25 per cent. of the mash, *i.e.* 12·5 per cent. of the total ration, gave as good results as equivalent amounts of maize meal. Feed consumption, utilisation and egg yield were equal. Groups of 45 hens were used. Economic conditions must decide whether potato flakes or maize is to be used.

The Effect of Ground Soya Beans on the Cold Storage Quality of Eggs. *A. E. Tomhave and C. W. Mumford. Poultry Sci.*, 1933, *12*, 37-41. (*Univ. Delaware, Newark.*)—Amounts of ground soya beans up to 10·4 per cent. in an all-mash laying ration do not have a detrimental effect upon the keeping quality of eggs in cold storage when the storage period is 4, 6 or 9 months, and the eggs are laid and stored in the month of May. Whites of eggs from the soya-bean rations kept as well during storage as those of eggs from the control ration.

STATISTICS

PRICES OF AGRICULTURAL PRODUCE, FEEDING STUFFS, AND FERTILISERS IN SEPTEMBER, OCTOBER and NOVEMBER 1938.

LIVE STOCK : Monthly Averages of Prices at certain representative Scottish Markets.

(Compiled from Returns received from the Department's Market Reporters)

Description	September			October			November		
	1st Quality	2nd Quality	3rd Quality	1st Quality	2nd Quality	3rd Quality	1st Quality	2nd Quality	3rd Quality
FAT STOCK :—									
*CATTLE—	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.
Aberdeen-Angus ..	45 6	40 5	40 0	45 4	40 5	40 0	46 8	41 7	40 0
Cross-bred (Shorthorn)	40 10	36 6	29 9	41 1	36 9	28 11	41 9	37 5	28 10
Galloway	40 1	36 5	32 0	38 7	35 8	..	38 6	35 3	..
Ayrshire	35 6	29 6	26 1	35 4	28 3	23 10	36 2	28 1	24 5
Blue Grey	45 8	42 3	39 6	47 11	43 8	40 0	47 8	44 0	40 0
Highland	..	..	..	..	..	..	..	28 0	..
	per lb d.	per lb. d.	per lb d.	per lb. d.	per lb d.	per lb. d.	per lb. d.	per lb d.	per lb. d.
†VEAL CALVES	10¼	3	..	11½	3	..	12	3	..
†SHEEP—	Hoggs under 60 lb. per lb. d.	60 lb. and upw'd. per lb. d.	Ewes per lb. d.	Hoggs under 60 lb. per lb. d.	60 lb and upw'd. per lb. d.	Ewes per lb. d.	Hoggs under 60 lb. per lb. d.	60 lb. and upw'd. per lb. d.	Ewes per lb. d.
Cheviot	8½	8	5½	8½	7¼	5¾	9¼	7¾	5¾
Half-bred	8½	7	4¾	8¼	7	5	8¾	7¼	5¼
Blackface	9½	8½	6	9¼	8	6	9¾	8½	6¼
Greyface	8¾	7¾	5½	9	7¾	5½	9¼	8	5½
Down Cross	8¾	8	5	9	8	5	9½	8½	4¾
†PIGS—	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.
Bacon Pigs	8 6	7 8	..	8 6	7 9	..	8 7	7 10	..
Porkers	9 6	8 8	..	9 6	8 7	..	9 8	8 7	..

* Live weight. † Estimated dressed carcase weight.

Live Stock: Monthly Averages of Prices at certain representative Scottish Markets—(*continued*).

Description	September 1st Quality	September 2nd Quality	September 3rd Quality	October 1st Quality	October 2nd Quality	October 3rd Quality	November 1st Quality	November 2nd Quality	November 3rd Quality
STORE STOCK:—									
Cattle—	per head	per head	per head	per head	per head	per head	per head	per head	per head
Aberdeen-Angus:	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.
Yearlings	14 8	11 6	8 0	14 2	11 8	8 9	14 6	11 0	8 3
Two-year-olds ..	17 8	14 13	10 3	17 3	14 11	10 10	17 8	14 4	9 17
Cross-bred (Shorthorn)									
Yearlings	13 6	10 6	6 15	13 1	10 0	7 5	13 7	10 1	7 1
Two-year-olds ..	16 5	13 2	8 7	16 15	13 13	9 16	16 17	13 6	9 16
Galloway:									
Yearlings	13 5	10 10	..	13 8	11 3	..	12 15	10 19	..
Two-year-olds ..	..	15 10	..	18 5	15 8	..	16 5	14 15	..
Ayrshire:									
Yearlings	11 8	9 5	7 10	11 6	8 16	..	11 5	9 15	..
Two-year-olds ..	14 10	12 0	..	13 4	11 15	11 0	..	..	..
Blue Grey:									
Yearlings	12 8	..	..	14 10	..	..	13 5	..	..
Two-year-olds ..	..	..	..	18 10	..	..	..	..	..
Highland:									
Yearlings	11 10	7 0	5 0	8 8	6 3	..	8 0	7 12	6 15
Two-year-olds ..	9 10	8 0	6 10	11 8	9 3	7 0	11 18	9 13	7 3
Three-year-olds ..	13 0	11 0	..	13 7	10 12	..	..	11 15	10 10
Dairy Cows—									
Ayrshire:									
In milk	26 7	19 15	14 13	27 3	20 5	15 8	26 16	19 15	15 2
Calvers	25 17	20 3	15 10	27 2	20 16	15 18	26 6	20 10	15 17
Shorthorn Cross:									
In milk	27 1	20 10	19 7	27 14	20 11	19 0	27 3	20 0	17 8
Calvers	25 8	18 2	..	26 3	18 12	18 8	26 0	18 5	17 1
Sheep—	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Cheviot Hoggs ..	..	19 0	15 0	..	..	..	19 11	14 0	..
Half-bred Hoggs ..	..	..	..	24 5	17 0	..	32 4	23 7	..
Blackface Hoggs ..	20 0	16 3	15 0	21 10	16 5	..	23 10	18 2	..
Greyface Hoggs ..	29 4	21 8	..	28 6	21 3	..	31 11	26 8	..
Down Cross Hoggs	31 0	26 0	..	30 0	25 0	..	31 11	25 7	..
Pigs—									
(6 to 10 weeks old)	29 11	18 5	..	30 11	18 8	..	28 6	17 3	..

DEAD MEAT: Monthly Average Prices at Dundee, Edinburgh, and Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

Description	Quality	September Dundee	September Edinburgh	September Glasgow	October Dundee	October Edinburgh	October Glasgow	November Dundee	November Edinburgh	November Glasgow
		per lb. d.	per lb d.	per lb d.	per lb d.	per lb d.	per lb d.	per lb. d.	per lb d.	per lb d.
BEEF:—										
Home-fed—										
Bullock or Heifer ..	1	6¾	6½	8¼	6⅝	6½	8⅜	7	6⅜	8½
	2	6½	..	7⅛	6⅛	..	7	6¼	..	7
Bull	1	5½	4¾	5⅜	5½	5	5⅜	5¼	4¾	5½
	2	5	..	4⅞	5	.	4¼	4¾	..	4¾
Cow	1	4½	4⅜	5	4½	4¾	5	4½	4½	5
	2	4	..	4	4	..	4	4	..	4
Irish—										
Bullock or Heifer ..	1	..	..	7	..	..	6⅞	..	..	6¾
	2	..	..	6⅛	..	..	6	..	..	6
Bull .. .	1	..	..	.	..	.	.	..	..	..
	2	.	.		..	.	..	..	..	..
Argentine Frozen—										
Hind Quarters ..	1	4	3⅝	..	4	3⅝	..	4	4	..
	2	..	3¼	..	..	3⅛	..	..	3⅜	..
Fore " ..	1	3½	3⅜	..	3½	3¼	..	3½	3¼	..
	2	..	2¼	..	..	2¼	..	..	2¾	..
Argentine Chilled—										
Hind Quarters ..	1	6⅜	6⅝	6	6⅝	6⅝	6⅛	6	6⅛	5¾
	2	..	5½	5	..	5⅞	5½	..	5¼	5⅛
Fore " ..	1	3⅞	3¾	3⅜	4	4	3⅞	4	4	3¾
	2	..	3⅜	3⅛	..	3⅛	3⅝	..	3½	3½
Australian Frozen—										
Hind Quarters ..	1	..	..	3½	..	..	3⅞	..	..	3⅜
	2	..	..	..	..	.	..	..	..	..
Crops	1	..	..	3⅛	..	..	3⅛	..	..	3⅛
	2	..	..	..	..	..	..	..	..	..
New Zealand Frozen—										
Hind Quarters ..	1	..	..	3¼	..	..	3¼	..	..	3¼
	2	..	..	..	..	..	..	..	..	..
Fore " ..	1	..	..	2⅞	..	..	2⅞	..	..	2⅞
	2	..	..	..	..	..	..	..	..	..
MUTTON:—										
Hoggs, Blackface ..	under 60 lb	10	7⅝	7⅞	10	7½	7½	9½	8⅜	8
	60 lb & over	9½	..	7⅛	9⅛	..	7⅛	9	..	7¼
" Cross ..	under 60 lb.	10	7⅝	7⅞	10	7½	7½	9½	8⅜	8
	60 lb & over	9½	..	7⅜	9⅛	..	7⅛	9	..	7¼
Ewes, Cheviot ..	1	..	5⅛	5½	..	5⅛	5⅛	..	5⅛	5⅜
	2	..	..	4¼	..	..	4¼	..	..	5¼
" Blackface ..	1	7	5⅛	5½	6⅛	5⅛	5⅜	6	5⅛	5⅝
	2	6½	..	4¼	5⅜	..	4¾	5	..	5¼
" Cross	1	5	5⅛	5½	4¼	5⅛	5⅜	4	5⅛	5⅝
	2	4½	..	4¼	..	..	4¾	..	..	5¼
Argentine Frozen ..	1	..	..	3½	..	..	3½	..	..	3⅛
	2	..	..	..	..	..	..	..	..	..
Australian " ..	1	..	4⅞	3½	..	4⅞	3½	..	5¼	3½
	2	..	3⅞	..	..	4	..	..	4¼	..
New Zealand " ..	1	..	..	4¼	..	..	4¼	..	..	4¼
	2	..	..	3½	..	..	3½	..	..	3½
LAMB:—										
Home-fed	1	10½	8⅝	9¼	11	8⅛	9⅛	..	..	9
	2	..	..	8¾	10	..	8½	..	..	8¾
New Zealand Frozen	1	..	7½	7¼	..	7½	7¼	..	7¾	7⅜
	2	..	6⅝	6¾	..	6⅝	6¾	..	6¾	..
Australian " ..	1	..	..	6½	..	..	6½	..	..	6½
	2	..	..	..	..	..	..	..	..	..
Argentine " ..	1	..	..	6	..	..	6	..	..	6⅜
	2	..	..	..	..	..	..	..	..	..

EGGS: Monthly Average Wholesale Prices at Aberdeen, Glasgow, Kilmarnock and Lanarkshire.

PROVISIONS: Monthly Average Wholesale Prices (per cwt.) at Glasgow.

(Compiled from Returns received from the Department's Market Reporter)

Description		Quality	Sept. s. d.	Oct. s. d.	Nov. s. d.
Aberdeen—					
Country	per doz.	1	1 5	1 6	2 2
		2	1 4	1 4	2 1
Duck	,,	1	1 6	1 6	2 2
Kilmarnock—					
Country	per doz.	1	1 7	1 10	2 3
Lanarkshire—					
Country	per doz.	1	1 11	2 0	2 6
Glasgow—					
Country	per doz.	1	1 7	1 10	2 3
		2	..	..	1 8
Irish—					
Northern Ireland	per 120	1	15 11	18 9	24 1
		2	14 10	17 7	22 7
,, (Duck)	,,	1	12 4	12 6	16 2
Free State	,,	1	13 3	14 9	21 0
		2	12 7	14 0	19 6
,, (Cold Stored)	,,	1	10 3	10 11	10 10
		2	9 9	10 3	10 3
,, (Duck)	,,	1	11 9	11 10	15 7
Australian	,,	1	..	12 7	13 9
		2	..	12 0	12 11
Belgian (Stored)	,,	1	10 1	10 9	10 7
,, (Pickled)	,,	1	..	..	10 4
Canadian	,,	1	..	13 0	10 11
Danish	,,	1	12 8	13 11	17 5
		2	12 2	13 4	17 2
,, (Stored)	,,	1	10 9	10 10	10 11
,, (Pickled)	,,	1	..	..	10 5
Polish	,,	1	7 10	7 9	7 11
		2	6 6	6 6	7 5

Description	Quality	Sept. s. d.	Oct. s. d.	Nov. s. d.
Butter—				
Australian	1	..	..	90 5
Danish	1	121 0	117 0	122 2
,, (unsalted)	1	124 0	120 9	128 2
Latvian	1	101 0	99 0	97 0
New Zealand	1	106 9	107 3	90 0
,, (unsalted)	1	108 6	109 6	93 7
Swedish	1	102 3	101 9	104 7
Siberian	1	85 0	95 0	90 5
Cheese—				
Cheddar	1	72 0	70 6	76 0
Cheddar Loaf	1	69 0	73 9	76 0
Dunlop	1	68 6	75 8	78 5
Canadian	1	61 3	62 9	61 7
New Zealand (Coloured)	1	58 3	58 3	56 2
,, (White)	1	58 9	59 0	57 5
Hams—				
Irish (Smoked)	1	162 0	139 6	132 0
	2	149 6	124 6	112 0
American (Long Cut, Green)	1	84 9	80 0	85 7
,, (Short Cut, ,,)	1	81 3	76 9	79 5
Canadian (Long Cut, ,,)	1	85 0	81 0	86 0
Bacon—				
Ayrshire (Rolled)	1	123 0	111 0	114 10
English Wiltshire (Green)	1	105 0	90 0	89 2
,, (Dried or Smoked)	1	110 6	96 0	94 5
Irish (Green, Wiltshire Style)	1	102 0	81 0	82 5
,, (Dried or Smoked)	1	108 6	89 0	90 5
,, (Long Clear)	1	113 0	91 0	94 5
Canadian Sides	1	86 0	74 9	72 10
Danish Sides	1	95 0	82 3	82 5
Dutch (Green, Wiltshire Style)	1	112 0	95 6	91 7
Polish (,, ,,)	1	97 6	88 0	85 7
Lard—				

FRUIT AND VEGETABLES: Monthly Average Wholesale Prices at Glasgow.

(Compiled from Returns received from the Department's Market Reporter)

Description		Quality	September	October	November
Fruit:—					
Apples—					
British—	per		s. d.	s. d.	s. d.
Lord Derby	barrel.*	1	8 3	..	..
Other Cooking	„ *	1	7 11	..	..
American	case.†	1	10 10	10 1	9 5
„	barrel.††	1	..	20 5	19 7
Canadian	case.†	1	..	11 6	8 6
„	barrel.††	1	..	16 7	15 3
New Zealand	case.†	1	7 6	..	..
Pears, Californian	case ‖	1	18 8	16 6	13 7
Blackberries	lb.	1	0 3	..	..
Damsons	„	1	0 2½	..	..
Plums, Victoria	„	1	0 5	..	..
„ Monarch	„	1	0 3	..	..
Vegetables:—					
Beet	cwt.	1	5 0	4 6	5 0
Brussels Sprouts	net.‡	1	5 7	3 6	2 6
Cabbage, Scottish	dozen.	1	1 5	1 3	..
„ Coleworts	„	1	1 0	1 0	1 0
„ Red	„	1	2 4	2 8	2 6
„ Savoy	„	1	3 6	2 5	1 11
Carrots, British	cwt.	1	12 0	11 9	10 10
„ Dutch	„	1	10 9	10 6	9 7
Cauliflowers—					
Broccoli, Cornish	dozen	1	..	..	5 0
Other British	„	1	3 2	3 11	3 11
Celery	bunch.	1	2 2	1 11	1 6
Cucumbers	dozen.	1	4 6	4 9	8 0
Greens	bunch.	1	..	0 6	0 6
Leeks	dozen bunches.	1	2 6	2 5	2 1
Lettuce, Cos	dozen.	1	1 6	1 3	1 3
„ Cabbage	„	1	1 6	1 5	1 1
Onions, *Spring*	bunch.	1	0 4	0 4	0 4
„ *Dutch*	bag.**	1	7 2	6 6	7 1
„ *Valencia*	case.††	1	9 8	7 11	8 8
Parsley	cwt.	1	11 0	11 6	12 0
Parsnips	„	1	9 3	11 6	8 10
Radishes	dozen bunches.	1	1 11	2 0	2 0
Rhubarb	cwt.	1	3 11	4 6	..
Spinach	stone.	1	3 0	3 0	3 5
Tomatoes—					
Scottish National Mark					
"A.A."	lb.	1	0 5¼	0 6¼	0 7
Other Scottish	„	1	0 4¾	0 5¼	0 6½
Channel Islands	„	1	0 2½	0 4¼	0 4½
Canary	„	1	..	0 2½	0 4
Turnips	cwt.	1	2 3	2 2	1 11
Vegetable Marrow	dozen.	1	3 11	4 6	4 10

* 56 lb. (approx.). † 40 lb. (approx.). ‡ 20 lb. (approx.).
** 7½ stone (approx.). †† 9 stone (approx.). ‖ 46 lb. (approx.).

Potatoes: Monthly Average Wholesale Prices per ton at Aberdeen, Dundee, Edinburgh, and Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

Market	Quality	First Earlies	Second Earlies	Late Varieties: Red Soils: Golden Wonder	Late Varieties: Red Soils: Other	Late Varieties: Other Soils: Golden Wonder	Late Varieties: Other Soils: Other
		£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
SEPTEMBER							
Aberdeen ..	1	..	2 11 3	..	..	..	2 10 0
Dundee ..	1	2 10 0	2 11 3	..	..	..	..
Edinburgh ..	1	..	2 13 9	..	..	..	2 15 0
Glasgow ..	1	2 10 0	2 11 11	..	..	..	2 15 0
OCTOBER							
Aberdeen ..	1	..	2 10 0	..	..	..	3 5 0
Dundee ..	1	..	..	..	..	..	3 5 0
Edinburgh ..	1	..	3 3 9	..	..	..	3 6 3
Glasgow ..	1	..	2 10 11	..	..	..	2 16 3
NOVEMBER							
Aberdeen ..	1	..	..	..	..	4 5 0	3 2 6
Dundee ..	1	..	..	..	..	..	2 18 6
Edinburgh ..	1	..	3 8 0	7 0 0	..	7 0 0	3 8 0
Glasgow ..	1	..	2 14 0	..	..	4 15 0	3 1 0

Roots, Hay, Straw, and Moss Litter: Monthly Average Prices per ton at Aberdeen, Dundee, Edinburgh, and Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

Market	Quality	Roots: Carrots	Roots: Yellow Turnips	Roots: Swedes	Hay: Rye Grass and Clover	Hay: Timothy	Straw: Wheat	Straw: Barley	Straw: Oat	Moss Litter
		s. d.	s. d.	s. d	s. d	s. d.	s. d.	s. d.	s. d.	s. d
SEPTEMBER										
*Aberdeen ..	1	..	..	..	51 3	..	..	..	28 9	..
†Dundee ..	1	..	ø20 0	..	70 0a 60 0b	..	43 2	..	43 2	48 9c
‖Edinburgh ..	1	..	..	..	60 0 60 0b	..	25 0	..	25 0	28 0
aGlasgow ..	1	..	..	..	57 6	62 6	35 0	..	35 0	31 3e
OCTOBER										
*Aberdeen ..	1	..	..	..	53 2	..	..	..	31 8	..
†Dundee ..	1	..	ø17 9	ø24 3	73 9a 60 0b	..	40 0	..	40 0	50 0c
‖Edinburgh ..	1	..	..	..	61 3a 60 8b	..	25 0	..	25 0	28 0
aGlasgow ..	1	..	..	..	67 6	75 0	35 0	..	35 0	31 8e
NOVEMBER										
*Aberdeen ..	1	..	..	..	62 0	..	..	..	34 6	..
†Dundee ..	1	..	ø14 5	ø18 10	77 0a 67 0b	..	38 0	..	38 6	52 6d
‖Edinburgh ..	1	..	..	..	73 0a 68 0b	..	25 0	..	25 0	..
aGlasgow ..	1	..	..	..	70 0	80 0	35 0	..	35 0	31 3e

* Ex farm, loose.
† Baled and delivered in town.
ø Delivered in town.
‖ Bunched straw, delivered.
a Baled and delivered.
b Delivered, loose.
c Dutch moss litter, at quay.
d " " delivered in town.
e Home moss litter, in 1½-cwt. bales.

FEEDING STUFFS: Monthly Average Prices per ton at Glasgow and Leith.

(Compiled from Returns received from the Department's Market Reporters)

DESCRIPTION	SEPTEMBER Glasgow	SEPTEMBER Leith	OCTOBER Glasgow	OCTOBER Leith	NOVEMBER Glasgow	NOVEMBER Leith
Linseed Cake—	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Home	8 8 9	8 5 0	8 6 7	8 2 6	8 11 6	8 9 0
Foreign	8 1 7	8 0 0	8 1 7	8 0 0	8 5 6	7 17 6
Decort. Cotton Cake ..	7 9 5	..	7 7 6	..	7 7 0	..
Undecort. Cotton Cake—						
Egyptian (Home manufactured)	4 18 9	4 18 9	4 13 2	4 10 0	4 8 9	4 9 0
Bombay (Home manufactured)	..	4 13 9	..	4 7 6	..	4 5 0
Palmnut Kernel Cake ..	7 5 0	..	7 5 0	..	7 5 0	..
Soya Bean Cake	7 0 0	..	7 0 0	..	7 0 0	..
Coconut Cake	7 13 2	..	7 15 0	..	7 15 0	..
Groundnut Cake, undecort.—						
(37 % Oil and Album.) ..	..	6 5 8	..	6 7 6	..	5 15 0
(40 % ,, ,,) ..	..	7 2 6	..	..	..	6 13 0
Maize Germ Cake, Home mfd.	6 8 9	..	6 11 7	..	6 11 3	..
Maize Germ Meal	5 14 5	..	5 15 0	..	6 2 0	..
Rice Meal	4 5 4	4 10 0	4 0 8	4 0 8	3 19 9	3 12 6
Bean Meal	7 7 10	7 10 0	7 5 0	7 10 0	7 11 0	7 10 0
Barley Meal	6 11 11	6 13 2	6 0 4	6 7 6	5 11 9	6 1 6
Fish Meal	15 0 0	14 16 3	15 8 9	15 8 9	15 10 0	15 10 0
Maize Meal—						
Home manufactured ..	5 11 3	5 8 2	5 8 2	5 5 8	5 10 9	5 10 0
South African (Yellow) ..	5 9 5	..	5 6 11	..	5 8 3	..
Locust Bean Meal	6 18 2	6 6 3	7 3 2	6 10 0	7 7 0	6 10 0
Maize Gluten Feed (Paisley)	5 15 0	..	5 15 0	..	5 9 0	..
Maize—						
Plate	4 12 2	4 7 6	4 10 0	4 6 6	4 14 3	4 12 6
African (White Flat) ..	6 0 0	..	6 5 0	..	6 5 0	..
Oats—						
Home	5 15 0	5 11 3	5 18 9	5 12 6	6 1 6	5 11 0
Plate	5 13 2	5 6 8	5 12 10	5 8 2	5 12 9	5 5 0
Barley—						
Home	7 0 0	6 10 0	..	7 10 0	..	7 10 0
Imported	5 12 1	4 18 4	5 1 11	4 18 9	4 13 0	4 10 0
Wheat—						
Home	6 0 0	5 7 6	5 12 6	5 4 5	5 11 6	5 1 0
,, (Poultry)	5 15 0	..	5 7 6	5 2 6	5 7 6	5 0 0
Imported	6 6 11	5 5 0	5 19 0	5 5 0	5 12 9	5 0 0
Middlings (Fine Thirds or Parings)	6 1 7	5 15 0	6 4 5	6 0 0	6 1 0	5 19 0
Sharps (Common Thirds)	5 1 11	5 4 5	5 15 0	5 8 9	5 17 3	5 6 0
Bran (Medium)	5 3 5	5 3 9	5 14 1	5 10 0	5 17 3	5 15 0
,, (Broad)	5 8 5	5 18 9	5 18 5	6 5 0	6 1 6	6 2 0
Malt Culms	4 8 9	4 10 0	4 10 0	4 10 0	4 15 0	4 10 0
Distillers' Mixed Grains (Dried)	..	6 8 9	..	5 10 0	..	5 13 0
Distillers' Malt Grains (Dried)	6 10 0	..	6 10 0	..	6 10 0	..
Brewers' Grains (Dried) ..	5 7 2	4 15 0	5 9 5	4 12 6	5 6 6	4 13 6
Crushed Linseed	15 17 6	..	16 0 0	..	16 0 0	..
Locust Beans (Kibbled and Stoned)	6 1 3	6 1 3	6 6 11	6 5 0	6 10 0	6 5 0
Beans—						
China	6 11 3	..	6 8 2	..	6 13 6	..
English	..	..	6 15 0	..	6 18 6	..
Egyptian	6 7 10	..	6 4 5	..	6 11 3	..
Rangoon (White) ..	5 15 0	6 0 0	5 15 0	5 12 6	5 15 0	5 10 0
,, (Red)	..	6 0 0	..	5 7 6	..	5 10 0
Pease—						
Calcutta (White)	9 6 3	..	9 5 0	..	9 2 6	..
Karachi (,,)	9 3 9	..	9 0 0	..	8 17 6	..
Feeding Treacle	4 13 9	5 5 0	4 12 6	5 5 0	4 12 6	5 5 0
Sugar-Beet Pulp	..	5 1 8	..	5 10 0	..	5 8 0
Linseed Oil, per gall. ..	0 3 3	..	0 3 6	..	0 3 6	..

FERTILISERS : Monthly Average Prices per ton at Glasgow and Leith.

(Compiled from Returns received from the Department's Market Reporters)

DESCRIPTION	Guaranteed Analysis	SEPTEMBER		OCTOBER		NOVEMBER	
		Glasgow	Leith	Glasgow	Leith	Glasgow	Leith
	%	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Nitrate of Soda *	N. 15·5	7 8 6	7 8 6	7 8 6	7 8 6	7 10 6	7 10 6
Sulphate of Ammonia (Neutral and Granular) * ..	N. 20·6	6 15 0	6 15 0	6 15 0	6 15 0	6 17 0	6 15 0
Calcium Cyanamide †	N. 20·6	7 0 0	7 0 0	7 0 0	7 0 0	7 0 10	..
Nitrochalk * ..	N. 15·5	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0
Superphosphate ..	P.A. 13·7	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6
" ..	" 16·0	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6
" ..	" 18·3	3 2 6	3 2 6	3 2 6	3 2 6	3 2 6	3 2 6
Ground Mineral Phosphate ** ..	P.A. 26	..	2 7 6	..	2 7 6	2 7 6	2 7 6
" " " ** ..	" 27·5	2 10 0	..	2 10 0	..	2 10 0	..
" " " ** ..	" 34	3 7 6	3 7 6	3 7 6	3 7 6	3 7 6	3 7 6
Potassic Mineral Phosphate	P.A. 18 Pot. 10	3 16 3	..	3 16 3	..	3 16 3	..
" " "	P.A. 20 Pot. 7·5	3 10 0	..	3 10 0	..	3 10 0	..
" " "	P.A. 21 Pot. 5	3 5 0	..	3 5 0	..	3 5 0	..
" " "	P.A. 18 Pot. 9	..	..	..	3 10 0	..	3 10 0
" " "	P.A. 18 Pot. 5	..	..	..	3 2 6	..	3 2 6
Kainit (in bags) ..	Pot. 14	3 8 6	..	3 8 6	3 2 6	3 8 6	3 2 6
Potash Salts ..	Pot. 20	4 0 0	..	4 0 0	3 12 6	4 0 0	3 12 6
" " ..	" 30	5 7 6	..	5 7 6	4 15 0	5 7 6	4 15 0
Muriate of Potash (on basis of 80 per cent. purity)	Pot. 50	9 5 0	..	9 5 0	8 10 0	9 5 0	8 10 0
Sulphate of Potash (on basis of 90 per cent. purity)	Pot. 48·6	10 12 6	..	10 12 6	9 15 0	10 12 6	9 15 0
Steamed Bone Flour	N. 0·8 P.A. 28	6 0 0	..	6 0 0	..	6 0 0	..
" " "	N. 1 P.A. 30	..	..	..	5 15 0	..	5 15 0
" " "	N. 1 P.A. 60	..	5 15 0	..	5 15 0	..	..
Bone Meal (Indian)	N. 4 P.A. 20	6 15 0	.	6 15 0	6 15 0	6 15 0	6 15 0
Potassic Slag	P.A. 12 Pot. 6	..	..	..	3 10 0	..	3 10 0
Basic Slag ‡ ..	P.A. 12	2 5 0	..	2 5 0	..	2 5 0	..
" " ..	" 13	2 6 0	..	2 6 0	1 19 0	2 6 0	1 19 0
" " ..	" 14	2 8 0	..	2 8 0	2 1 0	2 8 0	2 1 0
" " ..	" 15	..	..	..	2 3 0	..	2 3 0
" " ..	" 15·75	..	..	..	$2 10 0	..	$2 10 0
" " ..	" 16·5	..	..	..	2 8 0	..	2 8 0

Abbreviations :—N. = Nitrogen ; P.A. = Phosphoric Acid ; Pot. = Potash.

* Carriage paid, in 6-ton lots. † Carriage paid, in 4-ton lots.

** Fine grist, 90 per cent. fineness through prescribed sieve.

‡ Basic Slag :—At Glasgow—80 per cent. citric soluble and 80 per cent. fineness ; f.o.r., in 6-ton lots. At Leith—Non-citric soluble ; carriage paid in 6-ton lots in Mid and East Lothian.

$ Citric soluble.

ABSTRACT OF AGRICULTURAL RETURNS FOR SCOTLAND, 1933

Collected 4th June 1933 (and comparison with 1932)

CROPS

Distribution	1933	1932	Increase		Decrease	
	Acres	*Acres*	*Acres*	*Per Cent.*	*Acres*	*Per Cent.*
Total Area (excluding Water)	19,069,007	19,069,007	..	..	..	..
Mountain and Heath Land used for Grazing (*b*)	10,440,654	10,368,178	72,476	0·7	..	..
Total Acreage under Crops and Grass ..	4,613,708	4,622,217	..	..	8,509	0·2
Arable Land	3,030,080	3,046,163	..	..	16,083	0·5
Permanent Grass (*a*) For Hay	178,913	166,454	12,459	7·5	..	..
Permanent Grass (*a*) Not for Hay.. ..	1,404,715	1,409,600	..	..	4,885	0·3
Total ..	1,583,628	1,576,054	7,574	0·5	..	..
Wheat	78,386	52,072	26,314	50·5	..	..
Barley (including Bere)	59,808	68,868	..	..	9,060	13·2
Oats	855,857	867,374	..	..	11,517	1·3
Mixed Grain	1,769	1,613	156	9·7	..	..
Rye	2,792	2,624	168	6·4	..	..
Beans (to be harvested as Corn)	3,035	2,737	298	10·9	..	..
Peas	604	505	99	19·6	..	..
Potatoes	152,513	148,539	3,974	2·7	..	..
Turnips and Swedes	351,653	348,464	3,189	0·9	..	..
Mangolds	1,389	1,072	317	29·6	..	..
Sugar Beet	1,706	665	1,041	156·5	..	..
Cabbage	4,818	4,816	2	..	..	..
Rape	9,034	7,748	1,286	16·6	..	..
Vetches or Tares, for Seed	175	113	62	54·9	..	..
Vetches, Tares, Beans, Peas, Mashlum, etc., for Fodder	8,360	9,075	..	..	715	7·9
Carrots	574	501	73	14·6	..	..
Onions	151	132	19	14·4	..	..
Flax	44	13	31	238·5	..	..
Small Fruit	8,582	7,920	662	8·4	..	..
Rye-grass and other Rotation Grasses and Clover For Hay ..	391,497	397,116	..	..	5,619	1·4
Rye-grass and other Rotation Grasses and Clover Not for Hay	1,086,010	1,114,347	..	..	28,337	2·5
Total ..	1,477,507	1,511,463	.	..	33,956	2·2
Other Crops	3,988	3,374	614	18·2	..	..
Bare Fallow	7,335	6,475	860	13·3	..	..
Orchards (*a*)	1,013	1,000	13	1 3		

LIVE STOCK

	1933	1932	Increase		Decrease	
	No.	*No.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*
Horses used for Agricultural Purposes (including Mares for Breeding)	113,886	115,696	..	..	1,810	1·6
Unbroken Horses (including Stallions) One year and above	14,403	14,581	..	..	178	1·2
Unbroken Horses (including Stallions) Under one year ..	5,368	4,900	468	9·6	..	..
Total ..	133,657	135,177	..	..	1,520	1·1
Other Horses	15,826	14,920	906	6·1	..	..
Total of Horses ..	149,483	150,097	..	..	614	0·4
Cows in Milk	364,554	351,290	13,264	3·8	..	..
Cows in Calf, but not in Milk	53,478	53,458	20	0·04	..	..
Heifers in Calf	65,877	60,705	5,172	8·5	..	..
Bulls being used for Service	17,530	17,956	..	..	426	2·4
Other Cattle :—Two years and above	199,172	190,122	9,050	4·8	..	..
,, ,, One year and under two ..	318,124	300,184	17,940	6·0	..	..
,, ,, Under one year	274,902	259,548	15,354	5·9	..	..
Total of Cattle (*c*) ..	1,293,637	1,233,263	60,374	4·9	..	..
Ewes kept for Breeding	3,355,719	3,412,613	..	..	56,894	1·7
Rams to be used for Service in 1933	95,126	96,133	..	..	1,007	1·1
Other Sheep :—One year and above	939,351	962,961	..	..	23,610	2·5
,, ,, Under one year	3,390,948	3,414,717	..	..	23,769	0·7
Total of Sheep (*c*) ..	7,811,144	7,916,424	..	..	105,280	1·3
Sows kept for Breeding	21,969	19,772	2,197	11·1	..	..
Boars being used for Service	2,459	2,183	276	12·6	..	..
Other Pigs	142,600	143,370	..	..	770	0·5
Total of Pigs	167,028	165,325	1,703	1·0	..	..

(*a*) Any Crop or Grass grown in Orchards is also returned under its proper heading.
(*b*) Includes land in Deer Forests used or capable of being used for grazing.
(*c*) Including cattle and sheep grazed on Deer Forests.

ACREAGE under WHEAT, BARLEY (including BERE) and OATS in each COUNTY on 4th June 1933, with COMPARISON for 1932.

Counties	Wheat		Barley (including Bere)		Oats	
	1933	1932	1933	1932	1933	1932
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Aberdeen	68	9	4,197	5,781	176,881	174,856
Angus	15,347	11,344	5,116	6,535	55,194	57,895
Argyll	37	5	528	580	13,918	13,947
Ayr	1,046	632	39	18	33,117	33,288
Banff	58	7	3,017	3,521	45,273	44,872
Berwick	4,240	1,672	7,152	7,613	23,878	26,482
Bute	..	8	1	1	4,073	3,950
Caithness	3	..	289	331	25,562	25,558
Clackmannan ..	343	190	24	26	2,706	2,714
Dumfries	104	41	40	76	31,904	32,188
Dunbarton	449	342	13	20	5,685	5,639
East Lothian ..	7,606	4,819	9,917	10,460	13,548	14,966
Fife	15,616	11,321	6,348	7,292	39,184	40,442
Inverness	195	9	2,662	2,648	28,004	28,207
Kincardine	1,951	997	2,331	3,164	32,103	31,691
Kinross	368	201	74	64	5,789	6,015
Kirkcudbright ..	131	32	16	37	18,255	18,486
Lanark	2,329	1,674	32	46	32,760	32,953
Midlothian	5,990	4,404	2,063	2,391	17,896	19,195
Moray	1,818	674	3,828	4,403	25,398	26,210
Nairn	114	32	711	897	6,792	6,901
Orkney	..	..	2,481	2,746	29,959	29,457
Peebles	16	7	29	14	4,881	4,978
Perth	10,115	7,147	710	1,118	57,831	59,324
Renfrew	1,598	1,273	..	32	7,683	7,813
Ross and Cromarty	1,655	829	2,937	2,963	31,923	32,747
Roxburgh	2,110	935	3,655	4,295	21,579	22,074
Selkirk	3	5	25	21	3,272	3,048
Stirling	2,162	1,511	111	108	15,342	15,446
Sutherland	..	..	128	130	6,199	6,399
West Lothian ..	2,789	1,872	779	1,021	9,487	9,819
Wigtown	125	80	46	37	24,072	24,048
Zetland	..	..	509	479	5,709	5,766
Total ..	78,386	52,072	59,808	68,868	855,857	867,374

ACREAGE under POTATOES, TURNIPS and SWEDES and SUGAR BEET in each COUNTY on 4th June 1933, with COMPARISON for 1932.

COUNTIES	Potatoes		Turnips and Swedes		Sugar Beet	
	1933	1932	1933	1932	1933	1932
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
ABERDEEN	8,156	8,096	75,495	74,226	26	1
ANGUS	21,233	19,760	26,723	26,552	131	43
ARGYLL	2,486	2,657	4,368	4,389	..	..
AYR	8,880	9,200	6,512	6,259	..	1
BANFF	1,707	1,762	17,681	17,911	..	1
BERWICK	2,503	2,306	16,797	16,942	54	1
BUTE	1,022	1,065	1,100	1,067	..	..
CAITHNESS	1,032	1,036	9,586	9,507	..	..
CLACKMANNAN ..	399	399	671	680	1	5
DUMFRIES	3,149	3,451	13,470	12,813	..	..
DUNBARTON	2,273	2,282	1,195	1,161	3	..
EAST LOTHIAN ..	8,716	8,497	10,458	10,671	109	71
FIFE	18,420	16,954	17,626	18,030	1,003	419
INVERNESS	4,535	4,585	8,111	7,977	6	..
KINCARDINE	4,770	4,539	14,033	13,894	32	13
KINROSS	1,335	1,266	2,102	2,005	7	..
KIRKCUDBRIGHT ..	1,317	1,428	8,032	7,836	..	..
LANARK	6,894	6,899	8,469	8,260	2	..
MIDLOTHIAN	6,587	6,367	7,921	7,791	7	6
MORAY	1,717	1,794	11,938	12,164	135	17
NAIRN	296	275	3,435	3,507	19	5
ORKNEY	1,938	2,015	12,243	12,204	..	..
PEEBLES	339	327	2,322	2,346	..	..
PERTH	19,742	18,818	20,628	20,124	120	56
RENFREW	3,176	3,302	1,754	1,658	..	..
ROSS AND CROMARTY	7,139	7,011	12,625	12,641	36	15
ROXBURGH	1,501	1,337	14,451	14,333	2	..
SELKIRK	144	138	1,816	1,857	..	..
STIRLING	3,572	3,609	3,225	3,081	..	..
SUTHERLAND	942	975	2,333	2,310	..	..
WEST LOTHIAN ..	2,769	2,612	2,835	2,760	2	6
WIGTOWN	1,910	1,820	10,698	10,563	11	5
ZETLAND	1,914	1,957	1,000	945	..	..
TOTAL ..	152,513	148,539	351,653	348,464	1,706	665

ACREAGE under RYE-GRASS and other ROTATION GRASSES and CLOVER, and under PERMANENT GRASS in each COUNTY on 4th June 1933, with COMPARISON for 1932.

Counties	Rye-Grass and other Rotation Grasses and Clover				Permanent Grass			
	For Hay		Not for Hay		For Hay		Not for Hay	
	1933	1932	1933	1932	1933	1932	1933	1932
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
ABERDEEN ..	54,331	54,071	242,728	249,972	3,060	1,880	51,713	49,440
ANGUS	21,646	22,317	61,805	62,399	1,862	1,541	31,173	31,801
ARGYLL	11,584	12,067	14,114	15,693	15,717	14,849	49,137	48,029
AYR	24,259	25,425	46,215	48,863	22,656	20,729	158,194	158,161
BANFF . ..	11,575	11,030	61,659	62,341	691	467	13,410	13,519
BERWICK .	12,172	11,456	51,822	51,128	3,051	3,235	64,914	65,628
BUTE .. .	2,228	2,243	6,352	5,713	587	388	9,811	11,164
CAITHNESS ..	10,337	9,731	31,463	32,942	2,136	1,477	22,780	22,745
CLACKMANNAN .	993	1,149	1,669	1,670	1,193	1,596	6,550	6,284
DUMFRIES ..	19.978	19,325	48,515	48,695	19,291	19,850	102,937	103,395
DUNBARTON .	4,491	4,762	4,327	5,200	2,353	2,450	22,935	22,107
EAST LOTHIAN ..	7,590	8,622	17,971	17,851	1,853	1,198	26,628	27,549
FIFE	22,817	24,431	30,617	30,883	4,983	4,318	73,987	78,126
INVERNESS ..	11,401	11,391	24,228	23,564	10,461	10,664	56,423	57,202
KINCARDINE .	12,116	12,746	35,229	36,716	895	401	12,594	12,091
KINROSS .. .	2,801	2,846	6,949	7,012	886	828	10,965	11,204
KIRKCUDBRIGHT	11,156	10,424	40,230	37,370	13,661	12,988	82,746	88,948
LANARK	28,613	29,305	34,065	37,134	13,072	13,039	104 369	104,199
MIDLOTHIAN ..	9,662	10,222	18,306	18,887	3,217	1,630	42,106	42,728
MORAY	6,894	6,404	33,415	35,347	469	144	9,812	8,275
NAIRN	1,883	1,775	8,607	9,557	279	103	2,656	1,840
ORKNEY	11,760	11,067	32,818	33,832	1,257	1,133	15,256	15,163
PEEBLES ..	2,454	2,513	9,677	10,244	1,830	1,204	27,591	28,855
PERTH	29,267	31,155	57,447	61,366	13,354	12,388	103,475	99,775
RENFREW ..	6,960	7,112	6,161	6,574	5,532	5,826	44,241	44,096
ROSS & CROMARTY	12,283	12,212	33,567	35,763	4,266	3,467	29,611	28,782
ROXBURGH ..	10,684	10,080	48,493	50,310	7,649	7,786	62,962	62,198
SELKIRK	1,316	1,364	6,622	6,750	1,999	2,095	14,348	14,549
STIRLING ..	8,801	9,314	9,534	9,630	7,882	8,324	55,929	55,812
SUTHERLAND ..	4,509	4,503	5,927	6,194	1,785	1,787	8,576	8,268
WEST LOTHIAN ..	5,722	6,155	4,525	4,988	1,299	932	22,380	22,683
WIGTOWN ..	7,394	8,086	50,396	49,037	7,364	5,631	52,038	53,342
ZETLAND ..	1,820	1,813	557	722	2,323	2,106	12,468	11,642
TOTAL	391,497	397,116	1,086,010	1,114,347	178,913	166,454	1,404,715	1,409,600

NUMBER of HORSES, CATTLE, SHEEP and PIGS in each COUNTY on 4th June 1933, with COMPARISON for 1932.

COUNTIES	Horses *		Cattle †		Sheep †		Pigs	
	1933	1932	1933	1932	1933	1932	1933	1932
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
†ABERDEEN ..	21,281	21,458	177,954	173,088	396,247	429,432	19,375	20,017
†ANGUS	7,115	7,091	56,210	50,338	208,754	216,906	8,824	8,149
†ARGYLL	4,039	4,129	51,159	50,679	725,158	717,085	3,639	3,847
AYR	6,893	6,887	120,423	115,606	413,053	414,182	10,598	11,513
†BANFF	6,169	6,320	42,276	41,317	109,081	117,150	5,498	6,055
BERWICK ..	3,353	3,451	27,333	25,691	403,549	410,715	5,146	4,546
BUTE	919	936	9,367	9,133	45,493	45,176	500	595
†CAITHNESS ..	4,152	4,141	20,197	18,591	193,917	195,148	1,147	1,424
CLACKMANNAN ..	439	453	4,427	3,987	12,652	12,881	625	472
DUMFRIES ..	5,247	5,236	77,316	74,254	590,652	589,959	9,309	9,317
†DUNBARTON ..	1,202	1,197	14,159	13,539	73,999	72,266	1,639	1,318
EAST LOTHIAN ..	2,628	2,740	16,870	16,528	160,367	173,455	3,970	3,623
FIFE	6,613	6,681	53,675	48,555	156,559	164,742	9,083	8,623
†INVERNESS ..	5,788	5,865	43,817	42,883	508,320	506,648	1,963	1,885
†KINCARDINE ..	3,579	3,584	30,652	27,489	74,632	78,130	2,806	2,740
KINROSS ..	781	818	6,732	6,041	33,246	36,014	847	697
†KIRKCUDBRIGHT	3,421	3,450	62,542	60,921	404,311	402,886	11,581	11,767
LANARK	5,631	5,710	77,508	73,670	246,573	246,125	7,880	7,816
MIDLOTHIAN ..	2,566	2,650	19,938	18,999	194,724	202,392	14,730	13,291
MORAY	3,412	3,504	24,379	24,092	52,351	56,939	4,022	4,661
NAIRN	990	978	6,732	6,614	15,736	16,335	974	869
ORKNEY	5,434	5,500	37,079	36,217	64,882	69,537	1,232	1,718
PEEBLES ..	645	671	7,416	7,031	206,789	211,964	588	644
†PERTH	8,780	8,863	76,770	69,950	654,054	657,477	8,472	8,232
RENFREW ..	1,879	1,905	26,595	25,160	47,413	48,220	5,125	4,419
†ROSS AND CROMARTY ..	5,141	5,265	37,161	35,949	337,888	345,050	3,345	3,110
ROXBURGH ..	3,000	2,968	26,723	26,073	581,754	588,911	3,149	2,834
SELKIRK ..	463	475	4,293	4,071	190,880	191,635	389	380
STIRLING ..	3,110	3,035	36,265	34,054	130,698	132,137	3,224	2,843
†SUTHERLAND ..	1,612	1,655	8,397	8,375	218,723	211,700	346	430
WEST LOTHIAN	1,521	1,581	14,205	12,836	25,988	26,823	2,701	2,699
WIGTOWN ..	4,046	4,083	64,346	61,311	153,458	155,136	14,165	14,578
ZETLAND ..	1,808	1,897	10,721	10,221	179,243	173,268	136	213
TOTAL ..	133,657	135,177	1,293,637	1,233,263	7,811,144	7,916,424	167,028	165,325

* Horses used for agricultural purposes, mares for breeding, and unbroken horses (including Stallions). "Other Horses" on agricultural holdings are not included; the total for these in Scotland is given in the summary table on p. 1.

† Including cattle and sheep grazed on Deer Forests.

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EMPIRE AGRICULTURE

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THE agriculture of the British Empire is a comprehensive title. Agriculture is often spoken of by the townsman, overlooking the specialised character of its different branches, as if it were a single industry. Agriculture in the British Empire is a very complex mosaic, containing every variety of methods of production, great differences of efficiency, wide diversity of social structure and of natural conditions.

For the broadest possible survey a fivefold classification is perhaps adequate. There is, firstly, the agriculture of the British Isles, the present problems of which cannot be entirely disconnected from its history stretching back into the remote past. It is in the main a system of intensive agriculture, affected by enclosures, long-established systems of land tenure, and so on, but in particular suffering from relative neglect during the long period of the triumph of industrialism.

Then in certain British Colonies there are specialised branches of agriculture which have a respectable antiquity, such as sugar and cotton in the West Indies.

In India there is a vast population engaged in highly intensive cultivation, with on the whole a very low productivity per person engaged.

Agriculture in the Dominions, by contrast, is extensive; it is carried on over recently settled areas of new land, has a high output per person engaged, and is usually equipped with up-to-date mechanical devices.

The fifth heading of this classification would include the modern plantation production which has been developed in the last twenty years, especially in Malaya.

This fivefold division is not all inclusive, but it calls attention to the great differences in the agriculture of the 450 millions of people of the British Empire working on over 8000 million acres of land.

Unfortunately in every part of the Empire agriculture is suffering from depression and crisis. Compared with conditions in the years 1925-29, prices have fallen to levels previously considered impossible. The volume of physical production is, however, so great that people commonly speak of a crisis of over-production. Some of the advances in agricultural methods which have given rise to that description will be discussed later.

The character of the depression varies in different parts of the Empire. In Great Britain its roots go back into the period of the Industrial Revolution, while it is probable that the break-up of landed estates, unaccompanied by the other methods for supplying capital to agriculture, has been a contributory factor.

Depression in many of the agricultural industries that cater for world markets can be traced to the Great War. The combatant nations of Europe found it impossible to maintain normal agricultural production, and overseas countries were called upon for supplies. This led to a rapid development of production in the two Americas, in Australia, and New Zealand. With the return of peace, European nations have not only re-established their agriculture on its pre-war basis, but in many cases have developed larger production. As a result we have been forced to face an over-development in sugar and wheat which has been the cause of later troubles.

Apart from these special causes, the world economic crisis has stricken agriculture with special severity. The general fall in prices, coupled with factors of depression special to agriculture, has resulted in a heavier fall of agricultural prices than of prices of non-agricultural materials.

Many persons seek in the increasing productivity of agriculture the source of the trouble, and there is much to be said for their view.

In the first few days of January the *Evening Standard* published one of Mr Low's most remarkable cartoons. The drawing showed most of the nations in frenzied pursuit of a single elusive figure labelled "Customer," and the title of the cartoon was simply "1934." This cartoon drew attention in the most vivid way to the extraordinary position in which the nations find themselves in this the fifth year of the depression. There is greater productive power than at any previous period of the world's history, but world trade has shrunk to less than 30 per cent., by value of its 1929 level, and the producers of the world, whether industrial or agricultural, are anxiously seeking to preserve their home markets or to retain a share of the markets in other countries.

The views of great authorities differ as to the interpretation to be placed upon this present state of affairs. Some maintain that to imagine that supply will in general continue to outrun demand is to ascribe to the phenomena of the depression a permanence for which there is little warrant. These anticipate that unremunerative prices will decrease supply until it is hardly sufficient to meet

demand, that then prices will rise, purchasing power increase, and world prosperity will be restored on a familiar basis. To those who hold such views interference with the "natural" interplay of economic forces is merely to prolong the crisis by the use of ineffective palliatives. Others, however, believe that the glutted markets of the present are due to the cumulative effects of the industrial revolution, that these effects were masked for ten or fifteen years, first by the war and then by the need to repair war damage and to build up depleted stocks, but that the world's productive power has become so great that even if consumption can be steadily increased, supply will in future constantly tend to outstrip demand.

Before proceeding to consider this question, some attention must be paid to the danger of basing assumptions about agriculture upon the experience gained from the study of industrial production.

In manufacturing industry when prices become unremunerative it is always possible for a factory to reduce production by decreasing the number of shifts, or in extreme cases by temporarily closing down. The farmer is, however, very differently placed. Under the stimulus of falling prices for certain commodities he may attempt to alter his crops or his class of live stock. When, however, the depression affects almost all his products, his natural instinct is to try to secure the same money income by increasing his output.

Nothing can more vividly illustrate this tendency than the recent history of New Zealand agriculture. In 1929 the price of New Zealand lamb in London was 9d. per lb., and of New Zealand butter 173s. 9d. per cwt. These prices fell to under 6d. per lb. and 103s. per cwt. respectively in 1932, yet during this period New Zealand exports increased by about 42 per cent. for mutton and lamb and by 40 per cent. for butter.

The farmer instinctively feels that if he does not utilise his land it will begin to revert to nature, and he may thus lose not only his own labour but also that of the preceding generation who made the farm. This fact has been generally overlooked by many authorities when discussing the course of the present profound depression.

Although no attempt will be made in this article to suggest whether the exponents of *laissez-faire* are more likely to prove more in harmony with future events than those who are convinced that national planning is essential, yet if the problems of Empire agriculture are to be appreciated, it is necessary to realise that certain fundamental changes affecting world and Empire agriculture are taking place.

First let us consider some factors affecting the world picture. The contributions of the physical scientist to the developments of industrial production have been tremendous and continuous. In the years between 1750 and 1925 the output per man employed in certain industries had been increased many hundredfold. In this period we have seen a change from traditional and primitive methods of manufacture based on hand-power and wooden implements, to the

installation of 50,000 kilowatt turbo-generators to develop electrical power for factories in which man has become the servant of the machine.

Meantime the progress of agriculture has been so much slower that the world has remained almost unaware that here, too, an economic revolution has been taking place. Yet in the last thirty years changes have occurred in agricultural production which fully justify the use of the adjective "revolutionary." The slow progress of agriculture is by no means wholly due to the inherent conservatism of the farmer, for just as industrial progress has been conditioned by the availability of the results of physical science, so the rate of agricultural progress has been largely determined by the application of the results of biological research. In chemistry, physics, and mechanics, the results of experiments can generally be observed within a few minutes, hours, or days. In biology we are dealing with life itself and in many cases data cannot be wholly collected until the life-cycle of the experimental material has been completed.

For centuries agricultural production in the civilised world kept pace with the gradual increase in population and the very slow improvement in the standard of living through what may be described as extensive methods. Marshes and swamps were drained, forests were gradually cleared, and more land was procured for the plough and the hoe. The development of roads and canals brought fresh areas within the reach of the demand created by the young industrial areas. As demand rapidly increased, the steamship, together with the railroad, opened up the vast virgin areas of North and South America, of Australia and New Zealand, and thus secured an enormous expansion of land available for extensive production.

The nineteenth century may be regarded as the period of the conquest of new lands by western agriculture, but by comparison with twentieth-century developments, farming methods remained relatively static.

It is curious that fate should have arranged for the rapid falsification of the prophets of world starvation. The gloomy forebodings of Malthus were made at the very time when the marine and railroad engineer were combining to conquer for our civilisation almost empty territories greater than the whole domains of Imperial Rome. Of more direct bearing upon the present subject was the prophecy of Sir William Crookes, who in 1898 informed the British Association that world population had commenced to press against the means of subsistence and that a shortage of wheat could be expected to make itself seriously felt by the year 1931. Sir W. Crookes did, indeed, qualify his prophecy by saying that the discovery of effective means for the fixation of atmospheric nitrogen would postpone the evil day. The nitrogen in the air is now converted in many factories into agricultural fertilisers, but this factor has been of little relative importance to world supplies of wheat. In the very year

in which Crookes delivered his address, the patient work of the plant breeder was laying the foundations for the evolution of the new wheats, and in 1931 (Crookes' crucial year) world stocks of surplus wheat reached the fantastic figure of over 700,000,000 bushels.

Changes are now taking place at a pace which, if slow when compared with industry, are revolutionary for agriculture. In farming practice necessity is the spur which quickens invention. Thus actual shortage of labour rather than desire to save labour was the cause of the first important advances in agricultural engineering. About the middle of the last century labour was extremely scarce in both the middle west and the western States of America and in Australia, and in both these countries labour-saving machinery made its appearance. The combined reaper and binder is based on an American patent and was in general use in the States by 1870. A South Australian farmer, who had great difficulty in obtaining harvest hands, invented the stripper in 1846 and reduced his harvesting costs from 3s. 6d. to 6d. per bushel. Before the war some form of stripper, combine, or harvester, was in general use in Australia and had largely replaced other harvesting machinery in the western United States of America.

The modern combine harvester is the machine that has brought about the greatest economic changes in the world wheat situation. The tractor is another form of mechanisation which is revolutionising agricultural methods in many countries. It is especially important where oil fuel is cheap, *i.e.* the United States of America and Russia, and in countries where the severity of the winter renders the maintenance of horses a relatively costly business. For this latter reason the tractor is far more important in Russia and Canada than in Argentina and Australia where the farm horses, when not in work, can graze without much supervision throughout the year.

While machines are providing the most spectacular of the changes in modern agriculture, the effects of applied biology are probably more far-reaching.

In wheat, the plant breeders have produced for Canada early maturing wheats to overcome the difficulties that arise because of the short Canadian summer and the risk of early frosts. The celebrated Marquis wheat of Canada was one of the earliest of the new strains adapted by experiment to meet new conditions. These developments have added perhaps 100,000,000 acres to the world's possible wheat fields in Canada alone. In Australian wheat, biologists solved different problems with equal success. The problem there was to overcome the effects of rapid evaporation of moisture by producing a wheat having short straw and a minimum of flag. Federation wheat bred by farmers in Australia doubled the potential wheat belt. Further examples might readily be cited. For example, the sugar cane yields have greatly increased by careful crossing of varieties.

Biological research has developed the yield, not only of crops

and pastures, but also of farm animals. The production of beef, milk, eggs, wool have all been greatly increased where the application of modern scientific knowledge has been possible. Future developments will be attributable both to improvement of strains and to new knowledge in the sphere of nutrition. It would be possible to cite example after example of the effects upon animal husbandry of the feeding of small quantities of mineral or vitamin-rich substances.

Enough has been said to show clearly that biological as well as mechanical advances have had a deep effect upon the productivity of agriculture. This has been particularly marked in the younger countries, where relatively slight improvements in methods of extensive agriculture have had startling cumulative effects on world trade. In such countries so great has been the increase in quantities produced, so rapid the rate of expansion, that there are certainly grounds for speaking of "over-production" in certain sections of world agriculture. This phrase cannot, of course, be used in relation to human needs, but only to men's incomes and to the proportion of their means they are prepared to devote to purchasing foodstuffs when they also desire many other kinds of goods.

One economic consequence of mechanised farming is clear. The machine will displace farm labour, and since men's stomachs are only slightly elastic, the labour displaced will not easily be reabsorbed owing to a proportionate increase in demand. Unless, therefore, we suddenly follow the lead given by the Erewhonians and destroy all machinery, we must look forward to a decrease in the proportion of the world's population engaged in agricultural pursuits. But it is impossible to disregard the possibility that if the world fails to solve the problem of the proper distribution of its rapidly augmenting wealth, we may be driven to the Erewhonian method as the only feasible way to avoid the fate of Midas.

The mechanical improvements in farming have been applied so far mainly in the countries where man-power is scarce, and the output per man is high. This is natural, as in many countries where man-power is plentiful capital for farming is scarce, and there is less incentive to apply expensive new mechanical devices. Gradually, however, some of the many applications of machinery and the internal combustion engine to farming may be expected to affect even these countries; and biological and chemical developments will then have a much more rapid effect. The tendency must be, therefore, for the output from a given number of persons engaged in farming to increase.

The capacity for human consumption of many foodstuffs is relatively inelastic. In the case of cereals taken as a whole, the demand is probably highly inelastic, while for others, such as sugar, it is less inelastic. In comparison with wheat or rice one might describe the possible world demand for butter or oranges as capable of immense expansion. But even with such commodities the

possible limits of expansion are far more easily reached than in the case of manufactured goods. It is true that great masses of the world's population are still underfed. It is almost certainly true, however, that the increasing wealth of the populations of countries like India and China will be achieved through increasing the local production of foodstuffs. Countries which are specialised for producing wheat, meat, or dairy produce etc., for export will probably experience some increase of demand as prosperity begins to increase the purchasing power of Asia, but it is doubtful whether any great permanent expansion of demand, such as took place in the nineteenth century, is to be expected.

Turning now to changes especially affecting the Empire, it has to be recognised that we have reached the culmination of the change in the world's industrial structures that have been going on during the last decades of the nineteenth and the first part of the twentieth centuries. The United Kingdom is no longer in a position to rely on supplying the whole world with manufactures, in return for agricultural products and raw materials. This fact leads to two conclusions: firstly, that the United Kingdom should seek to develop within limits her own agricultural production; and secondly, that she must be increasingly concerned to secure satisfactory markets for her manufactured goods among such countries as can provide her with favourable outlets. This latter point emphasises the special importance of Empire trade to Great Britain.

It is also clear that the Dominions have to face a less elastic demand for many farm products. The excesses of economic nationalism have greatly contracted the import demands of Europe, and have stimulated totally uneconomic agricultural production.

One result of extreme agricultural protection in Europe has been to increase Dominion dependence on the United Kingdom market. Thus, whereas in 1924-29 Great Britain purchased about 60 per cent. of world exports of butter, restrictions on the Continent have now raised this figure to 80 per cent. These changes have increased the economic dependence of the several parts of the Empire upon one another.

Economic nationalism in its present exaggerated forms is not necessarily permanent, but it has to be faced as an important factor in the immediate future. The overseas countries look to the good sense of the principal industrial countries not to continue to cut down international trade in agricultural products to the present low levels, because if they do, they will necessarily cut off the markets for their manufactures. Moreover they impose a great burden upon their consumers, who have to pay high prices for the necessities of life.

The position of the British Empire in regard to most agricultural products is one which should enable methods of co-operation to prove of the greatest value to all its parts. There are, however, certain important products in which the Empire taken as a whole

is a nett exporter. Canada and Australia together normally export much more wheat than the total import demand of the whole Empire, and thus for wheat international solutions must be sought. Owing to the accumulation of stocks, mainly in the United States of America and Canada, prices have been at an extremely unsatisfactory level for a number of years. There is no likelihood of a permanent improvement until these surplus stocks are disposed of. The London Wheat Agreement of August 1933 was concluded with this aim in view, and its satisfactory working is of great importance, since the price of wheat exercises a profound influence not only on the purchasing power of the wheat exporting nations but on the whole of world trade.

The three Southern Dominions export far more wool than the Empire can utilise, and here again it is the world market and not that of the Empire alone which must concern the producers. Fortunately the revival in wool prices during the present season has come to the rescue of the Australian, New Zealand, and South African pastoralists. Wool at 8d. per lb. involved producers in the Dominions in extreme difficulties, but a rise of 100 per cent. in the price of wool has lifted the depression in that branch of Empire agriculture. It is estimated that the clip in Australia will be worth £50 millions, against only £34 millions last year, although the quantity is smaller.

The Empire is a nett importer of meat, dairy produce, fruit, and of most other farm products. Frozen mutton and lamb and dairy produce play for New Zealand the rôle that wheat plays in Canadian agriculture, and wool and wheat in Australian. The United Kingdom is the only market for mutton and lamb, and prices have shown some improvement since January 1933, as a result of the limitation on imports agreed to at the Ottawa Conference. New Zealand and Australia agreed not to ship to the United Kingdom in 1933 more mutton and lamb than that supplied during the year ended 30th June 1932, while foreign countries were limited to declining quarterly percentages of their supplies in the same basic period. These restrictions have been valuable in their effects to the United Kingdom and the Dominion producer, but of course they have involved self-denying ordinances upon the latter. Prices for beef have shown a less satisfactory response. A most interesting recent development is the success with which trial shipments of beef are being sent to the United Kingdom from the Southern Dominions in a chilled instead of frozen condition.

The production for export of butter and cheese in the Dominions has expanded very greatly since 1913. Imports of Empire butter, for example, were only 850,000 cwt. in that year and were over 4½ million cwt. in 1933. Moreover this expansion has continued progressively over the last few years, the import of Dominion butter last year being the highest on record. This expansion, it is hardly necessary to say, brings problems of its own at a time when prices

are so low. The average price of New Zealand and Australian finest salted butter was about 82s. per cwt. for 1933, compared with about 130s. in 1930, and prices at the end of 1933 were even lower than the year's average. It is not the place here to go into controversial questions of policy. Obviously, however, for the dairy farmer of the Dominions future prospects are still obscure and the position very difficult.

But indeed the problems and possibilities of each of the major branches of Empire agriculture merit separate treatment for which an article devoted to each would be hardly adequate. Poultry and eggs, maize, fruit, tobacco, and cotton are each of great importance to whole districts and populations of the Empire.

The dependence of Overseas Empire agriculture on the British market is very great in nearly all products. Great Britain intends to develop the profitability of its own essential agricultural industries. Nothing has been said here about Britain as one of the agricultural producers of the Empire, because readers of this JOURNAL are well acquainted with current difficulties and policies. Co-operation between the Mother Country and the Overseas Empire in the fundamental research that has given rise to the increased productivity in agriculture since the war has been exceedingly close. If the problems of the future lie as much in the sphere of marketing as of increasing productivity, the interests of all parts of the Empire are in a co-operation at least as intimate, and needing at least as much forethought and goodwill.

STRAWBERRY CULTURE—I

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Introduction.—Until the incidence of various serious diseases among strawberries rendered it impossible to grow them satisfactorily, they were the most profitable outside crop.

The area under strawberry cultivation in Scotland has shrunk very considerably, especially in those districts which were once regarded as the centres of the industry. The demand for dessert fruit is always good, and as canned strawberries are very good sellers, there is a very promising outlet for increased production.

Strawberry culture demands much more attention to detail than most horticultural crops. The amount of hand labour is relatively great, and as this labour must be skilled in the methods of cultivation and in picking, casual labour is not satisfactory. Planting, thinning, weeding, and picking must all be done by hand, and the crop is not so easily picked or marketed as many other fruit crops. It is not wise to commence strawberry growing in districts where suitable labour cannot be obtained. For a period varying from six to sixteen weeks gangs of pickers and weeders are necessary.

The strawberry may be satisfactorily grown at greater altitude than any other fruit crop. The main considerations in deciding whether a district is suitable are nature of soil, suitability of climate, availability of labour, and nearness to markets.

Soil.—Although strawberries do best on a good sound loam, they may be satisfactorily grown on soils varying from fairly heavy clays to light sands.

Soils with a comparatively high organic content—such as mild peat soils—are productive, provided the excess of nitrogen is balanced by phosphates and potash. Soils which may be described as sandy peats have given very good results, but in the absence of correction, peaty soils lacking in mineral material may produce rank growth. For the production of early berries a sandy soil is best, especially if it contains a high percentage of organic matter ; but better crops and better quality fruit are obtained from heavy soil.

The nature of the subsoil should be considered, as extremes of soil may be corrected by the type of subsoil. A light sandy soil overlying a heavier subsoil would be suitable, as also would a heavy soil overlying a porous subsoil. Considerable difficulty occurs, however, when both soil and subsoil are either extremely light or very heavy.

While it is not essential that the selected soil be rich, it is an advantage to have a fairly high organic content. Strawberries have to complete their vegetative growth and fruiting in a very short space of time—four months at most—and the actual fruit production is carried out in an even shorter time, hence it is essential at the critical periods of development to have plenty of readily available food material and moisture. Not only is the water-holding capacity of a soil important, but even of more moment is the ease with which water is distributed in the soil.

Stony soils are satisfactory, provided the stones do not interfere with the cultivation nor with the rooting of runners. The soils should on no account be denuded of stones where they occur naturally. Though the chemical composition of the soil is not of great moment—this can easily be altered by the application of fertilisers—its physical nature and condition have a very marked effect on the success of the crop. Special stress must be laid on soil drainage, with which is associated aeration, the height of the water table, and the presence or absence of harmful materials.

It is generally accepted that the strawberry does best in a soil which is either neutral or slightly acid. This may be true, but it is equally true that the strawberry can at least tolerate slight alkalinity. It is unwise to grow the crop in chalky soils or on soils to which heavy applications of lime have been recently given.

Climate.—Strawberries may be successfully cultivated at altitudes varying from 50 to 800 feet above sea-level, but it does not necessarily follow that all districts within these zones will suit the crop requirements so far as climate is concerned. It is not

safe to plant strawberries in districts where the winter is severe and prolonged, especially if the soil be heavy. The crop grows satisfactorily, but if frost penetrates deeply there is always the danger of winter killing, owing to the uprooting of plants by the heaving of heavy soils. If the rainfall is above 50 inches and the winter long and cold, with a comparatively great number of wet days, plants are liable to die out.

Aspect.—Crops grown on a slope towards the south give earlier berries and may ripen two to three weeks earlier than those on flat land ; but heavier crops are sometimes grown on land sloping towards the north. In these days of rapid transport the production of early berries in northern districts is not so desirable as it once was, so no special benefit may accrue from a sheltered or southerly slope. Land sloping to the south and the south-west is also liable to suffer from drought. Steep slopes are a serious disadvantage if the system of cultivation adopted entails the maximum use of horse or mechanical labour, but for hand labour this is not so serious, though the application of manure may present considerable difficulty. Much depends on the climate and on the situation. Land lying at the foot of a slope or near a watercourse may be subject to late frosts. This may not seriously interfere with the blossoming nor with the total yield of fruit, but it is an accepted fact that the first-opened blooms are more fertile and produce better berries. Uneven fertilisation produces poor fruit with hard knots.

Drainage.—Of all the soil conditions none is more important than drainage. Efficient drainage frees the land of surplus moisture, enables cultural operations to be carried out over a greater part of the year, and ensures the deeper rooting of the crop. Drained soils have a greater capacity for retaining capillary moisture and water moves more freely in all directions. Such soils induce a much greater root development than do badly drained soils and the crops are not so liable to suffer from drought. The level of the water table varies considerably on all soils, but is almost invariably highest during the winter months. If the land is not drained it sometimes happens that the plants are standing in water during part or the whole of a season, and this leads to winter killing. The drains should be at least 2 feet 6 inches deep, which will ensure that the water table will not rise within 2 feet of the surface unless the site is entirely unsuitable—subject to flooding from a watercourse or from neighbouring soils. If, owing to situation or to the nature of the soil or of the drainage, water lies long on the surface of the land, it is very difficult to secure a good stand of plants. The drainage should be so arranged that not more than 15 feet is allowed between the minors, and the tiles should be $2\frac{1}{2}$ to 3 inches in diameter.

Rotations.—Strawberries should always be grown as a crop in the rotation. When the amount of suitable land is limited, this

presents some difficulty, but on the other hand it is extremely unwise to grow the crop successively on the same land. The pernicious practice, common in some districts, of growing strawberries on the same land time after time with at most an interval of two years between the successive crops of strawberries, has led to serious consequences. These do not operate to such an extent when the old plants are removed and burned, but are intensified when the old crop is ploughed-in.

It is unwise to plant strawberries in dirty land, and a satisfactory cleaning crop should be taken shortly before planting up the crop. It is questionable, however, whether potatoes are a suitable crop for this purpose. Turnips are satisfactory, but best of all is a green crop like vetches, mustard, clover, or ryegrass. If a green crop is used it is essential to get it ploughed or dug-in some time before planting the strawberries, so that the consolidated plant bed may be obtained. An application of nitrolim (2 cwt. per acre) a few weeks before ploughing assists in breaking down the rigidity of the old plants, and hastens decay.

Preparation of the Soil.—No fruit crop is more expensive in annual upkeep than the strawberry and good preparation always repays the grower. Land foul with perennial weeds should not be planted, and if subject to chickweed should be given another cleaning crop before strawberries are set in it.

Until quite recently the clearing of perennial weeds was an expensive operation, costing as much as £25 per acre to hand-clean the ground, but this can be done now at a comparatively small cost. Sodium chlorate applied at the rate of from 3 to 4 cwt. per acre towards the end of September will destroy all perennial weeds, except sheep's sorrel or ordinary dockweed. No grower has any excuse for planting really foul land with strawberries.

Strawberries are planted in autumn and in spring. The autumn planting extends from July to October, and spring planting takes place in March and April. On land where frost penetrates for a prolonged period to a greater depth than 6 inches, spring planting is preferred. In districts where the winter is cold and prolonged, and accompanied by a fairly heavy rainfall, it is very difficult to secure a stand of plants from autumn planting. Spring planting allows of autumn preparation, which is a decided advantage, and in general should be the method followed in Scotland.

Deep cultivation ensures a greater water-holding capacity, and this is important in growing a crop like strawberries which require a great amount of water in a very short time. The autumn ploughing should therefore be at least 7 inches in depth and at the same time stable or farmyard manure should be ploughed-in at the rate of 40 tons per acre. An exception should be made in the case of light sandy soils, which should be manured in spring as there is a danger of loss of manurial ingredients during the winter.

The spring cultivation should aim at the production of a fine tilth

to enable moisture to pass freely and at a close contact between the soil and subsoil at the cultivation level, so that the reserves of moisture in the subsoil may be drawn on. The cross ploughing in spring should be shallow.

The fibrous nature of the root demands that water be lifted from the lower level of the soil very quickly. Moisture is only able to move freely in a well-consolidated soil, and it is only possible to draw on the reserves of moisture in the subsoil if the soil be compacted. Spring treatment will also include two crossings with harrow or cultivator, but neither of these should be to a great depth. For the actual planting it is necessary, early in the spring, to obtain a good surface tilth, but if the soil be worked to a greater depth than 2 or 3 inches it may become too dry at planting time, owing to drying winds in March. For this purpose the disc harrow is a very suitable implement; the first harrowing should be done with the plough furrow and the second crosswise. The number of harrowings will depend on the condition of the soil and, to a great extent, on the previous condition of the land. It is rarely necessary to use the chain harrow. The compacting is best done by means of a roller. If the soil is at all light, rolling is indispensable, but where the land is heavy it is not wise to roll until the soil is in a good condition, and usually two or three days should intervene between harrowing and rolling.

Trenching Subsoil.—There does not seem to be much advantage in bastard trenching or subsoiling; in fact, on a very light soil this may be harmful because contact is not established with the subsoil. The greater the depth to which the soil is cultivated, the greater the difficulty of obtaining contact with the subsoil—particularly on a light soil. Any benefits obtainable from trenching or from subsoiling are only of a temporary character and might be permanently obtained by drainage. Where trenching is adopted it is necessary to ensure that the subsoil is kept below, as burying the top soil has resulted in considerable loss of yield on some holdings.

Preparation of Land out of Turf.—It is sometimes necessary for a grower to break up lea land for strawberries, but there are several disadvantages in adopting this method. It is particularly difficult to get the consolidated planting bed, and in addition turf-land is more likely to be infested with white grubs and leather-jackets. The sod should first be taken off with a skim plough and buried as deeply as possible. A dressing of lime (one ton to the acre) might with advantage be given some time before digging or ploughing. If the presence of wireworm and leather-jackets is feared, spread and plough-in naphthalene at the rate of 4 cwt. to the acre. The land should be cross-ploughed in the spring to a depth of about 2 or 3 inches only, otherwise the turf will be brought to the surface. Much more persistent rolling will be necessary on turf-land than on land which has been previously cultivated. It is possible to control leather-jackets after plants have been inserted

by using the "poison bran mash." For strawberries the best mixture is: $\frac{1}{2}$ lb. Paris Green, 25 lb. bran, and 2 lb. treacle. Mix the dry Paris Green with the bran; thin down the treacle with $1\frac{1}{2}$ gallons water, stir this into three-quarters of the bran mixture, and dry off with the remainder. This mixture should be scattered about the field after planting.

Manuring.—The strawberry crop occupies the land for at least two seasons, and often for a much longer time, and it is rather exacting as far as humus content is concerned; a high organic content improves the physical condition and aids the activity of the soil bacteria. Under most conditions of planting and cultivation it is impossible to get farmyard or stable manure incorporated with the soil after planting, therefore the whole of the animal manure must be applied before planting. Stable manure is considered to be superior to farmyard manure for this purpose. If the soil is heavy, peat-moss litter manure is very satisfactory, but on a light sandy soil only well-decayed straw stable manure should be used.

Manuring may take the form of an application of animal manure alone or of animal manure plus fertilisers. Many growers seem to consider that it is unnecessary to apply artificial manures during the first year, but it is desirable that an application of artificial manures such as superphosphate and potash be given to balance the excess of nitrogen in the stable manure. On land out of turf it may be necessary to apply only artificial manures. Land which has been repeatedly cropped with strawberries may be exhausted, but where old strawberries are turned in and the land replanted the following year without any rotation of crop or with only one intervening green crop, there is little need of specific application of farmyard manure.

Fresh manure, though it improves the tilth of a clay soil, should not be applied in preparation for strawberries, as it is liable to be polluted with weed seeds.

It is not possible to give directions for the quantity or nature of artificial manures suitable for all soils, as so much depends upon the nature of the soil and on the previous manuring and cropping. Varieties have certain characteristics in relation to manures. Some varieties are very strong growing, and the presence of a high nitrogenous content in the soil leads to soft luxuriant growth, accompanied by susceptibility to disease. The amount of nitrogen applied to the soil has a marked influence upon the carrying quality of the fruit. An application of phosphates induces bigger root development, especially on a clay soil. Potash manures are useful in enabling plants to resist drought, and therefore are of great service in obtaining a stand of plants on dry soils.

The artificial manure for application previous to planting should have a composition approximate to—

From 2·5% to 3% nitrogen.
,, 5% ,, 7% of soluble phosphoric acid.

From 3% to 5% of insoluble phosphoric acid ; and
,, 8% ,, 10% ,, potash.

A satisfactory mixture and one easy to remember and to mix is—

¾	cwt.	sulphate of ammonia :	21% nitrogen.
3	,,	superphosphate :	13·75% sol. phos. acid.
1	,,	steamed bone flour :	¾% n. and 27·5% insol. phos. acid.
1	,,	sulphate of potash :	48·5% potash.
¼	,,	sand.	

This will give a composition of 2·85 per cent. of nitrogen, 8 per cent. of soluble phosphoric acid, 4·59 per cent. of insoluble phosphoric acid, and 8·09 per cent. of potash. Such a mixture may, however, be made in various ways and from various materials. Dried blood and tankage are valuable additions to the nitrogenous content in manures, but they are expensive.

As previously mentioned, it is usually considered that slightly acid soils are more suitable than alkaline soils for strawberries. It is equally true that strongly alkaline manures are not suitable for application to the crop. Where it is desired to apply lime to the soil for the purpose of improving the mechanical condition, this should be done with the previous crop. If the previous crop was a grass or clover crop, or a green crop such as vetches, the lime will not be detrimental to the succeeding strawberry crop. As a phosphatic manure, basic slag is not so suitable as superphosphate. For application during the growing season, bone meal and steamed bone flour are very useful if applied in July and August, the period during which new root formation takes place. Of the nitrogenous manures, sulphate of ammonia is best for general application, but much advantage may arise from the application of nitrate of soda at the rate of a ½ cwt. per acre during the blossoming period. The benefit is not so much in improvement of growth as in fertilisation of flowers. In addition to the manures given before planting, it is advisable to apply annually a good artificial mixture at the rate of 6 cwt. per acre in which the potash content should be supplied by sulphate of potash. Muriate of potash is not so satisfactory and kainit or potash salts are often detrimental.

Methods of Planting.—These are dependent on several factors, the most important of which are the type of cultivation to be adopted (whether by horse or by spade), the slope of the land, and the severity of the winter.

The several methods are: the Single-row System, the Matted-row System, the Bed System, the Single-hedge System, and the Double-hedge System.

Single-row System.—With this method, horse cultivation or cultivation by a mechanical cultivator is possible. The rows should be 24 to 30 inches apart and the plants set at from 15 to 18 inches asunder. In a strictly maintained single-row system

all the runners arising from the original plants are removed. The original plants therefore develop a number of crowns and produce massive bunches of foliage. A modification of this method is to allow two runners per plant to tiller within the row.

The Matted-row System.—At planting time the matted-row system is identical with the single row, but most of the runners that arise from each plant are allowed to root where they can, and there is little attempt to restrict them in number or to arrange them for distance. In strong growing varieties this method gives rise to considerable difficulty in cultivation. A restricted matted-row system, in which only the initial runner of each stolon stem is allowed to take root, gives better results than the unrestricted anchorage of runners.

The Bed System.—The bed system is commonly adopted in districts where the cost of land is high, labour relatively plentiful, and good markets near. Practically all the cultivation and attention is performed by hand. It is the only practicable method on hilly ground. Another reason for the adoption of this method in many parts of the world is the danger of winter killing. A long winter accompanied by heavy rainfall and periodic frosts is liable to cause winter killing by throwing the plants out of the ground. In the single-row system, plantations in districts where such conditions apply become very uneven owing to serious mortality. The bed system is more satisfactory where an autumn and spring mulch is impossible.

The cost of planting and maintaining the crop under the bed system is comparatively high. The number of plants required per acre is considerably higher than under the single-row system—at least one and a half times as many—and all work after the first year has to be done by hand. On the other hand, a much heavier yield per acre is obtainable.

It requires from 10,000 to 15,000 plants per acre on the single-row system, and 24,000 to 28,000 on the bed system.

Single-hedge System.—The runners may be planted in spring or in autumn, but this system is more common in districts where autumn planting is practised. The rows are 2 feet apart, while the plants are set 3 feet asunder, and this requires 7260 runners to plant an acre. In the following July two strong runners per plant are selected, and layered in the rows, one on each side of the parent plant. Other runners are rigorously suppressed. The plants will then be approximately 1 foot apart, giving 21,780 per acre. This method has the advantages that the initial cost of planting is not high and the introduction of new runners in the year following the original planting enables the plantation to be profitable for a longer period.

Double-hedge System.—The plants are set in autumn, but in this case a distance of 3 feet is allowed between the plants and 4 feet between the rows. In the following July four initial runners are

selected per plant and pegged down. The best guide is to mark off a 2-foot square surrounding the parent plant, and to anchor a runner at each corner. When completed there will be groups of three rows each with rows 1 foot asunder and 2 feet between one set of three and the next one.

The initial planting takes 3630 per acre, but when layering is completed there will be 18,150 plants per acre.

Marking-out the Land.—On the single-row system it is only necessary to mark-out lines every 24 or 36 inches, but in the bed system a more complicated marking is required. The bed system may be either a two- or three-row bed, and the latter is first described. The marker is so arranged that it can mark three rows with an interval of 14 inches between each, and a fourth row at 28 inches from the previous one, which allows of two spaces of 14 inches and one of 28 inches. The three rows, planted 14 inches apart, constitute what is known as "the bed," while the space of 28 inches between one bed and the next is called "the strawberry road." As the plants grow and form large crowns, those in the outside rows encroach on to the roads, and the 28 inches may be reduced to 22 inches or even less. This fact must be taken into account in laying-out the land, as with several strong-growing varieties these roads, which permit passage for wheelbarrows and allow of access to the beds, may be reduced considerably, so that a greater distance between beds is necessary in such varieties as Oberschlesien, Brenda Gautrey, etc. For convenience of working, the bed system is sometimes arranged so that there are only two lines per bed and plants are allowed to find root between the two outside rows. In this method the land is laid-out in the same manner, but the middle row is not set-out at planting time, but fills itself in the following year.

Propagation.—Strawberries are propagated by means of runners. The mother plants throw out aerial stems which develop a cluster of leaves at each second node; these, if brought into contact with the soil, anchor themselves, the first plant becomes pegged down and other plants are formed in succession. The first one to "tiller-down" throws out stems, which may in turn form runners. It is therefore a simple matter to obtain quite a large number of runners from an individual plant. Runners should be taken only from one-year-old plants and it is not advisable to allow the runners to develop at will. The ease with which new plants are obtained often leads to a lack of care in selecting the best stock. It is advisable to hand-peg the layers, but where this is not possible, it is advisable to limit the number of runners produced to five per plant. It is becoming so difficult to obtain satisfactory plants that growers might consider the possibility of establishing nursery beds for their production. Hand-pegging may take the definite form of layering into turf placed near the mother plants, or the placing of flat stones on the stolons just behind the first node.

The growing point of the stolon should be nipped to prevent further production. Some authorities consider that it is better to leave the plants in the beds until the land is ready for planting, while others maintain that it is better to lift the plants and heel them in for some time previous to planting. In many cases heeling-in is certainly an advantage, as new rootlets are produced when the young plants are heeled-in. Certain diseases are passed on from the parent plant to the runners during the autumn, and where autumn planting is not practicable this usually results in contamination of the runners in the propagation beds. If the young plants be removed and heeled-in, it is possible to avoid infection. Runners should be taken only from one-year-old plants. Occasionally novices take runners from two- or even three-year-old beds, but except for the purpose of obtaining a stock of a particular variety, this practice should not be adopted. In heeling-in, two points must be carefully observed: the plants must not be set any deeper than they would be in actual planting, and they should be heeled-in singly. A shallow trench should be prepared with one vertical side against which the young plants can be laid with the roots spread out, soil pushed forward to cover the roots, and the ground firmed with the foot. If plants have been a long time in transit it is advisable to give them a chance to recuperate. Before planting them out permanently, lay them along the row in contact with one another, where they may remain for a fortnight or three weeks to enable the plant to resume the absorption of moisture and the roots to regain turgidity. A much larger and more fibrous root system is produced on light than on heavy soils and this is an advantage on transplanting.

In some districts it is difficult to obtain good, strong, well-rooted plants for August or early September planting, but by taking "cuttings" in June or July excellent plants can be obtained. This method has been practised in private gardens for many years, and is now gaining favour with commercial growers. The "cuttings" are taken just when the runner roots are forming or after they have produced a few short roots. They should be put in frames allowing 5 inches between the rows, and 3 inches between the "cuttings" in the rows, and must be watered thoroughly and shaded for a week or so. They root quite readily and make good plants for August planting, and are not so liable to infection, so that this method might with advantage be adopted for building-up disease-free stocks (*e.g.* in case of Red Core Disease this might prevent infection).

Lifting and Preparing the Plants for Planting.—The preparation of the plants is not only the most important but also the most seriously neglected operation in connection with planting. The plants should be lifted carefully with a trowel, strawberry chisel, or hand fork. The soil should be shaken from them, the old stems, together with any dead leaves, removed, and the roots dressed.

The dressing of the roots consists in drawing all the roots straight down, at the same time pulling all the leaves upwards. Trimming back all the roots is advisable, as the plants can thus obtain a grip of the soil more easily and are not so likely to suffer from drought.

Planting.—The implements used in planting are the dibber, the trowel, and the spade; the most expeditious being the dibber and the spade. The strawberry dibber is a pointed iron-shod implement having a swollen part on the leg about 3½ inches from the point which prevents it being pushed into the ground too deeply. After trimming, the plants are inserted well down in the hole and brought slowly upwards so that they are just covered to the top of the roots. The crown should never be buried nor should any part of the roots remain above the surface. The dibber should be inserted at a slight angle, the plant placed in the hole, and the dibber inserted again an inch or two away from the first hole and pressed in to close the original hole. A small spade is necessary; this is pushed into the soil at an angle and lifted upwards, thus opening a narrow V-shaped trench in which the roots can be spread out satisfactorily. Experienced workers may plant anything from two thousand to four thousand plants per day provided the plants are first laid in position, but this is not customary in Scotland. It is not an advantage for the person placing the plants to get too far ahead of the planter. In the actual planting, the worker straddles the row, takes the plant in the left hand and the dibber in the right, being always careful to see that the plant is quite firmly planted. Where plants are set loosely, a very poor stand results. It should be impossible to pull up a correctly-planted plant by the leaves.

Choice of Varieties.—The majority of British varieties are self-fertile, but a variety commonly grown called "Tardive de Leopold" is a pistillate variety. It is not so important to insist on mixed plantations in this country as in other parts of the world. There is considerable advantage in obtaining the plants from new districts and it is always wise for growers to try out new varieties. Continued propagation from one stock without change leads to reduction in vigour. This may be avoided by obtaining plants from other districts or grown on a different type of soil. Amongst the various varieties the favourites in Scotland are Ruskin, Lord Overtoun, Scarlet Queen, and Paxton. Among newer varieties Emperor of Brazil, Western Queen, Brenda Gautrey, and Cessnock are very promising. It is essential for growers to test-out newer varieties for themselves, making the bulk planting of the older tried varieties. New seedlings are much more vigorous at first than in later planting, and this leads to the supposition that they are bound to be free from disease, but this is not necessarily the case.

After Care.—If the planting has been done in spring, it is an advantage to prevent the plants fruiting in the first year. Persistent cultivation during the first year is essential. Stirring the

soil lets in air, encourages root formation, and enables moisture to reach the plants. The implements best suited for the cultivation will depend upon the system of planting. The Paxton hoe is the most efficient implement, but cultivation can be more expeditiously carried out with the Planet Junior or by a horse cultivator. A heavy soil becomes hard and baked in summer, the subsequent cracking leading to the breaking of the roots, whereas a sandy soil may dry up to a considerable depth. In both circumstances the production of a soil mulch is beneficial. The slogan "ply the hoe" applies more to the cultivation of strawberries than to any other fruit crop. All perennial weeds should be carefully removed and an application of bone meal or steamed bone flour should be given in July.

Root Production.—There are two main periods of root production—from spring to midsummer and midsummer to autumn—and certain differences are observable between the root formation in autumn- and that in spring-planted runners.

Autumn Planting.—Autumn-planted runners immediately form new rootlets some distance behind the tips of the runner roots, and at the same time develop a considerable number of primary roots from the base of the crown. This coincides with a browning of the original runner-root system. During the winter root formation is inactive, but the death of the old root system proceeds.

In March root and shoot production recommences. Both primary and lateral root formation proceed until mid-May, when the production of the finer lateral roots is most in evidence. During June browning of the older roots takes place and is succeeded by the emission of new primary roots from the base of the crown and by an abundant development of laterals, which continues until the end of September.

Spring Planting.—The active growth of feeding roots and the manufacture of a few primary roots proceeds until July, by which time the original runner roots are brown. The root system is not so large as in autumn-set runners, but from mid-July until September spring-set plants make a large root system, and this coincides with maximum shoot growth.

For the proper production of root growth. upon which is dependent maximum shoot growth and the formation of numerous crowns, artificial manures should be applied early in spring and again after harvest in July or August. After harvest the beds should be weeded at least twice, the long trailing runners which creep over the roads should be cut back with a hook and the roads should be dug.

Spring Tillage.—After the winter has passed the beds should be weeded and cleaned. In a young plantation many of the runners may be allowed to remain, but where the rows are kept distinct, surplus runners are removed and the spaces between the rows hoed. Remove the old leaves and apply artificial manures.

In the second year it is necessary to weed the beds twice before picking and twice afterwards, following which the trailing runners are cut and strawberry roads dug. Thorough working of the soil between the rows and the drawing of soil slightly round the plants tends to maintain them in a profitable state for a longer period than would be the case if this were omitted.

Mulching.—When strawberries are grown on the single-row system and the plants kept to a single row, or even when they are allowed to mat, a straw mulch is sometimes applied in the autumn or just before blossoming, according to the object aimed at. In districts where the soil freezes to a considerable depth or where there is a combination of frost with a heavy soil, the mulch is sometimes applied in the autumn. To some extent this prevents the soil freezing, and even if it does freeze the thaw will be much more gradual and danger to the roots minimised. It is generally supposed that mulching is a guard against frost in spring, but it may be quite the reverse. The young buds and blossoms may push through the straw into growth and be more subject to frosting. A mulch in contact with the plants holds moisture, the soil remains cold for a longer period, and ripening is delayed. Though mulching is useful for retaining moisture and protecting the fruit from damage during rain, it does not really help in the cultivation of the crop. With a suitable material a mulch may act as a manure, but the presence in it of many weed seeds will cause serious trouble. The most suitable mulch is the comparatively long straw shaken out for manure obtained from stables where the horses are well bedded. It is not wise to apply this material immediately as there is a danger of scorching, so it should be exposed for a week or two before application. In the spring mulching the litter should be placed only round the plants, but in the autumn mulch the plants are completely covered, and it is then necessary to remove it from the plants previous to the fruiting period.

Picking, Packing, and Marketing.—Strawberries have a very short season of growth and also of picking. By a combination of early and late varieties on heavy and light lands, together with southerly and northerly aspects, the picking season on a holding may be extended considerably. The limits are usually from six to ten weeks. When the crop is good the picking season is particularly busy. Boys and girls or women make the best pickers; trained pickers are much better than novices, and most growers attempt to keep the same workers year after year. In the actual picking it is advisable to have a foreman who can take charge of a squad of twenty-five to thirty pickers, supply them with baskets, load up the wheelbarrows, and see to their dispatch to the packing shed.

Strawberries should never be allowed to become dead ripe on the plants unless they can be marketed within twenty-four hours.

Strawberries are picked separately for dessert and for jam

manufacture, the husks being left on for table fruit but removed for jam purposes. For dessert fruit the stem is pinched about ¼-inch behind the calyx and when picking the fingers do not come into contact with the fruit. The best quality fruit is now marketed in two-pound baskets, which are packed in trays for dispatch to market. The packages used include the one-pound punnet, and the two-, three-, and four-pound chip baskets packed in crates or on trays. Larger packages than these are not used in Scotland. It rarely happens that a greater proportion than three-quarters of the total crop is suitable for marketing as dessert fruit, and the rest is dispatched to the jam factory. Previously it was the custom to pack jam fruit in one cwt. or half cwt. kegs, but this method is being discontinued. Factories in the neighbourhood of the centres of production prefer the fruit in two- or four-pound chips on trays, and this practice is becoming universal. For canning, two-pound chips on trays are preferred.

BACTERIA IN RAW AND IN PASTEURISED MILK

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In the sale of graded milks, certain standards are imposed with regard to the bacterial content · for instance, at any time before its delivery to the consumer, Certified Milk shall not contain more than 30,000 bacteria per c.c., nor any coliform bacillus in one-tenth of a c.c., while Pasteurised Milk must not contain more than 100,000 bacteria per c.c. While no limiting bacterial standard has been hitherto imposed on ordinary market milk which is exposed for sale, some progressive milk organisations have paid, in recent years, a differential price for farm milk on a basis of its bacterial content and keeping quality. This circumstance has acted as a stimulus to the production of clean milk among the suppliers of these milk organisations, but it has also caused concern to some producers who despite their efforts to conform to the demands of this special market may be informed on occasion that the bacterial numbers in their milk exceed the desired limits, and they may be at a loss to understand the reason. Obviously the milk at some stage has received an accession of organisms which are directly responsible for the high count, but a difficulty may arise in determining the particular source of infection. Reference to the kinds of organisms which are present in the milk will often provide a clue.

Immediately it leaves the udder of the cow, milk is subject to infection from the environment, from the cow's coat, from the hands and person of the milker, and from the utensils. Hence the better the hygienic conditions under which milk is produced and handled, the lower will be the germ content, and the better its flavour and keeping properties. But it is not possible even by the

exercise of rigid cleanliness to produce a germ-free milk, since even before it leaves the mammary gland, milk contains living organisms.

Intra-mammary Bacteria.—In the milk of most healthy cows, intra-mammary organisms (represented chiefly by innocuous cocci) are relatively few in numbers, and contribute an unimportant fraction to the bacterial content of market milk. But the freshly-drawn milk of some cows, apparently in normal health and with no obvious udder infection, may contain high bacterial numbers; a few such cows in a milking herd of average size would materially increase the bacterial count of the mixed milk issued from the farm, and in the case of Certified Milk—where the milk of the whole herd is not mixed before bottling—might make the standard of 30,000 bacteria per c.c. in selected bottles difficult of attainment. Thus a producer, who in spite of the rigid practice of hygienic measures still finds difficulty in securing a low-count milk, should take steps to find out whether the defect is not traceable to individual cows which consistently yield a high-count milk. Our investigations have shown that such a circumstance is by no means uncommon.

A fault in market milk which occasionally causes considerable trouble is the development of a burnt or caramel flavour. This defect has been shown to be due to the infection of the milk by a variety of the common lactic acid bacteria (*S. lactis var maltigenes*). Infection of the milk usually takes place from unsterilised utensils or from an impure water supply, but recently we have investigated two cases of burnt-flavoured milk in which the infection was due to intra-mammary organisms of the lactic acid type. The milk of the affected cows, obtained under strict aseptic conditions, developed a strong burnt flavour when held for 12 hours at room temperature. By pasteurising the freshly-drawn milk the development of the burnt flavour was prevented.

Udder infections will of course result in milk of higher bacterial numbers than normal, and though the implicated bacteria may not always be registered on the official agar plate, they may be enumerated by the Breed Smear method. The milk of cows suffering from mastitis may, even before it appears to be physically altered, contain streptococci in numbers as high as 100,000 per c.c. Though these organisms are non-pathogenic to man, yet the milk which harbours them has a poor flavour, and should be withheld from the market. (It should be noted that the milk of cows affected with the mild form of mastitis caused by *Streptococcus epidemicus* may, if consumed in the raw state, cause septic sore throats.)

The causal organisms of contagious abortion and of tuberculosis are not numerously present in the milk of affected cows, and are not ordinarily registered by the official plate count, but as these organisms are pathogenic for man, the milk should be effectively pasteurised to render it safe, or should be excluded altogether. Scholl and Torrey (4) have found that *Brucella abortus* when present

in the milk gland produces definite changes which considerably lower its efficiency.

Occasionally organisms of the coliform type may gain entrance to the milk gland, and proliferating there, give rise to an infected milk. Cases of this kind have been reported in America, the milk of affected cows developing a peculiar taint and causing gassy curds in cheese-making. An intra-mammary infection in a Grade A (T.T.) herd of a gas-producing organism recently came under our observation. Milk obtained aseptically from individual cows of this herd when incubated for 14 to 20 hours at 37° C. produced a very gassy curd. The infection seems to have been derived from an infected pasture. The field on which the cows were continuously grazed during the outbreak had been previously flooded with river water into which the sewage discharge of a large industrial town had gained access. The milk could not conform to the coliform standard for Grade A (T.T.) milk.

External Infections.—The great majority of organisms present in market milk are of external origin, and because of this the careful producer is able to restrict materially the bacterial content of his milk supply. Any oversight in the production and handling of milk will result in a definite increase in bacterial numbers, and by reference to the types of organisms which are present it is often possible to indicate in the case of high-count milk the most probable sources of infection.

Organisms which frequently occur in contaminated milk are the coliform bacilli, and in the graded milk scheme the tenure of B. coli is presumably regarded as a measure of the hygienic conditions under which the milk has been produced. Coliform bacteria occur in large numbers in cows' fæces—about 90 per cent. of the associated bacteria being of the coliform type—and in market milk fæcal contamination, arising directly from an infection of fresh voidings or indirectly from dried particles of dung and soiled debris from the cow's coat, must be regarded as the chief source of these bacteria. The foremilk, especially during the winter months, frequently contains coliform organisms ; about 50 per cent. of the total bacteria present in the first-drawn milk may, as we have found, belong to this type ; for example, the foremilk of one cow gave a total count of 27,000 bacteria per c.c. and a coliform bacillus count of 15,000 per c.c.

Imperfectly cleaned utensils, and more particularly the milk cooler and the milk churns, constitute another source of coliform bacteria; the coliform organisms associated with unsterilised utensils are chiefly of the B. aerogenes type. B. aerogenes is *par excellence* the cause of gassy curds in cheese-making. Other sources of coliform organisms in milk are soil contamination, an impure water supply, and certain farm foods. Except therefore in the case of comparatively rare intra-mammary infections, coliform bacteria can be practically eliminated from the milk supply by

an effective grooming of the cow's coat in advance of milking time, by rejecting the foremilk, by cleaning and sterilising all utensils used in the production and transportation of milk, and by using a pure water supply. One may note that the presence of coliform bacteria in milk depresses its keeping qualities.

Ropiness or sliminess in milk is a troublesome dairy infection which most frequently occurs in the warmer months of the year. Though ropy milk is not ordinarily prejudical to the health of the consumer, yet its uninviting appearance causes its immediate rejection. Bacteria which can cause milk to become ropy may be derived from several sources ; from soil, from the water supply of the farm, from the dusty air of the byre, from the litter, from the food of the cow, and from the washings of utensils. Probably the most common ropy milk organisms are *B. viscosum*—usually derived from infected water—and certain members of the coli-aerogenes group which are frequently found in cattle foods such as grains, cakes, and meals, bran and hay. Recently Stark and Stark (5) have shown that the presence of minute amounts of a bacteriophage derived from plant material will cause ordinary forms of B. aerogenes to become slimy. This fact may explain sudden outbreaks of ropy milk.

Clean methods of production, effective grooming of the cow's coat, cleaning the flanks and udder of the cow before milking, rejection of the foremilk, milking with clean hands, effective sterilisation of the utensils, and low temperature cooling of the milk, will eliminate a ropy milk infection.

If the air of the byre is dust-laden while milking is taking place, the germ content of the newly-drawn milk will be increased. Formerly this source of contamination was considered of little importance since relative investigations appeared to show that during routine byre operations the air of the cowshed seldom contained more than 200 bacteria per litre, and that the implicated organisms belonged mainly to the type which resist desiccation, *e.g.*, certain micrococci, organisms of the *B. subtilis* group, and mould spores. Recently, however, improved laboratory technique has shown that in addition to these bacteria a group of organisms which form very small colonies on agar plates is frequently present in the dust of the air of the byre. On account of their tiny size these colonies have been called "pin points."

The souring of milk at ordinary temperatures is due mainly to the common lactic acid organism, *Streptococcus lactis*. Infection of the milk commonly arises from the utensils, and more especially from the milk churns. It is this organism which is responsible for much of the spoilage of market milk in warm weather. Milk which is produced under cleanly conditions from healthy cows, which is handled in sterilised utensils, and which is kept at a low temperature contains few lactic acid bacteria.

Bacteria in Pasteurised Milk.—When market milk is effectively

pasteurised, a marked reduction in bacterial numbers present in the raw milk is normally achieved. The temperature of pasteurisation (145-150° F. for 30 minutes) ensures the destruction of pathogenic bacteria (both of bovine and of human origin), as well as the majority of the common milk bacteria, but it permits of the survival of certain heat-resisting organisms. If the producer's milk contains high bacterial numbers, the probability is that the milk after pasteurisation will also have a higher count than normal, because many of the bacteria will be of the type that will withstand the selective-heat treatment.

Certain spore-forming organisms, some micrococci (especially those which form lemon-yellow colonies), heat-resistant strains of B. coli, and occasionally occurring anaerobic bacteria can survive the pasteurising process.

While most of these heat-resistant bacteria withstand the pasteurising process, they do not grow at the pasteurising temperature. About ten years ago, however, it was observed that certain bacteria could actually grow and multiply during the pasteurising process. Because of this peculiar temperature relationship they have come to be known as *thermophilic bacteria*. The true thermophiles are spore-forming in habit, have an optimum growth temperature of 55° C. and over, and compose a distinct type of rod-shaped bacteria, which when present in considerable numbers are easily recognised. Normally they occur only in small numbers in raw milk, usually less than 1000 per c.c. Yet it has frequently been found that in samples of milk taken from the holder of a pasteurising plant that has been operated continuously for several hours without interrupting the process to clean the plant, thermophilic bacteria may be present in numbers which exceed a million per c.c. In this case the relatively few thermophiles in the first batches of raw milk have served to infect the pasteurising equipment so that, with ineffective control, conditions have been presented which favour their rapid development. Many of these thermophiles will not develop on routine agar plates incubated at 37° C., and this circumstance explains why their presence in pasteurised milk was so long in being recognised. By plating out representative samples on special agar and incubating at 63° C., by making a reductase test under an oil seal at the pasteurising temperature, and by direct microscopic examination, the relative numbers of thermophilic bacteria can readily be established. The presence of thermophilic bacteria in considerable numbers may cause the milk to acquire a disagreeable flavour, to result in an increase in the acidity of the milk during pasteurisation, and on occasion to coagulate the casein. Experimental work in America (3) has shown, however, that thermophilic bacteria have no sanitary significance and that, so far as can be determined, they are not injurious to health.

The continuous use of the pasteurising equipment for more than 2 hours without flushing out the apparatus with hot water, the

presence of foam on the surface of milk which is left behind when the holder is emptied at the end of the 30-minute period, milk residues left on the walls of the heater due to the cooking on of some of the milk solids, prolonged holding of the milk at pasteurisation temperature, repasteurisation, and the presence of dead ends in the pasteurising equipment are some of the reasons given by Breed (2) for the occasional presence of large numbers of thermophiles in pasteurised milk.

It has been shown that the source of these thermophilic bacteria in milk is external, since they do not occur in the udder. They are frequently present in the dust of the air, and doubtless gain access to the milk from the atmosphere of the milking shed. They may also come from the food of the cows, from the fæces, and from the person of the milker. They may occur in the utensils, especially in unsterile moist cans. As they may occur even in high-grade raw milk—although in small numbers—their complete elimination from pasteurised milk is scarcely possible, but by careful processing and by systematic treatment of the pasteurising plant, one may restrict their multiplication and so limit their number. Holding the raw milk at low-storage temperatures prior to pasteurisation is a useful method for controlling the development of many milk bacteria, and while many thermophilic bacteria die off at low temperatures, yet a considerable percentage may survive. On the other hand, failure to cool milk in summer weather may result in a considerable increase in organisms of the *Streptococcus thermophilus* type.

Some samples of pasteurised milk when plated out on agar and incubated at 37° C., may show a profuse development of "pin-point" colonies, *i.e.* colonies which are just visible or appear very small when viewed by a hand lens. Ten years ago Ayers and Johnson (1) found that a thermophilic organism named by them *Lactobacillus thermophilus* was the cause of pin points in the milk of a large dairy organisation. This organism grew rapidly at the pasteurising temperature (145° F.). Pin-point colonies, however, are more frequently due to heat resistant (or thermo-tolerant) streptococci, which are present in the raw milk, and which resist but do not grow at the pasteurising temperature. Generally pin-point colonies are observed more frequently in winter than in summer milk.

Infection from Pasteurising Equipment.—A necessary condition for the attainment of a low bacterial count in pasteurised milk is the thorough sterilisation of all equipment. It has already been observed that a large infection of thermophilic bacteria may take place from milk solids deposited on the inner surfaces of the heater and holder. Contamination of the milk after it leaves the holder may take place from the cooler, from the bottle-filling machine, and from the bottles themselves, if these are not actually sterile. In one commercial plant it was found that the milk taken from the base of the cooler had a bacterial count 14 per cent. greater than the

same milk just as it left the holder, and when it reached the bottle its bacterial population had increased by a further 13 per cent. This experience emphasises the necessity of sterilising thoroughly all parts of the milk plant equipment, and indicates the value of plate counts in checking the efficiency of pasteurisation and detecting some unsuspected sources of contamination in the milk plant itself.

Low temperature cooling is an important factor in restricting bacterial development during the storage of pasteurised milk. If the temperature is allowed to rise above 50° F., the bacterial population may show an increase of 5 to 10 per cent. at the end of 24 hours, even though the maximum temperature does not exceed 60° to 65° F.

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AN EARLY SCOTTISH IMPROVER

ALEXANDER M'CALLUM, O.B.E., M.A., LL.B.

UP to the time of the Union of the Parliaments in 1707 little change had taken place in methods of Scottish agriculture since medieval days. The system of land tenure was unaltered; leases were almost unknown, and tenants were subject to feudal restrictions and to the performance of compulsory services which greatly interfered with their freedom and with their work upon their own holdings. Each tenant's land was intermingled with that of his neighbours in the ancient "runrig" system, and as the rigs might be, and often were, redistributed annually, there was no incentive for any holder to improve in any way the condition of those rigs he might occupy for only one year. Lands were unenclosed, rigs being separated only by intervening "baulks" or ridges of uncultivated land overgrown with thorns and weeds. To keep the crops from being interfered with during the growing season the cattle had to be herded off them, and after harvest all the cultivated land became common grazing for the cattle of all the tenants and cottars. There was no "artificial" grass and the grazing was of the poorest description. Winter feed was very meagre and the beasts were often literally starved between grazing seasons. Farm implements of all sorts were of the most primitive kind, and cultivation was wretched. The main crops were oats and bere, and these were grown year about on the "infield," which got all the dung available; while of the "outfield" one-third was cropped with one

or other of these grains for three years in succession, and then allowed to lie fallow for two years, in the vain hope that so it would recover fertility. It is not surprising to learn that yields of two or three times the amount of seed sown were regarded as satisfactory.

After the Union communication with England became commoner and more frequent, and knowledge of the better methods of farming then being adopted there began to drift northwards. Naturally, such knowledge became available and made appeal first to the land-owning class, who saw the results of the improved methods in England when they travelled to and from London, or visited the estates of English friends.

One of the first of Scottish lairds to be impressed by English and Continental methods of farming was William Mackintosh of Borlum, who, both by personal demonstration on his own land and by his writings, did much to awaken the interest of Scottish landlords and farmers in the possibilities of improvement.

The story of his life is fascinating. He was the eldest of the five sons of William Mackintosh of Borlum, a small estate in the parish of Dores, Inverness-shire, and was born about the year 1662. When he was about ten he and his next younger brother were entered as students at King's College, Aberdeen. There he remained until he was fifteen, and in the Degree Lists of 1677 he took the first place. Thereafter he appears to have gone to England, and it is not unlikely that he spent some time at Oxford. At all events, he himself claims to have been on friendly terms with the Hon. Robert Boyle, who was then living near Oxford, and who was the most celebrated natural philosopher of his time. Mackintosh became friendly too with the family of Edward Reade of Ipsden House, Oxfordshire, and later married a daughter, Mary, by whom he had two sons, Lachlan and Shaw, and three daughters

A strong supporter of the Stuart cause, he is believed to have left England at the Revolution in 1688, and to have spent some years in the French army, where he gained distinction. He must have been back in his own country before 1698, for in that year he is named—as William Mackintosh younger of Borlum—in a Commission of Fire and Sword granted to the chief of his clan against Macdonald of Keppoch ; and in 1704 he was a Commissioner of Supply for Inverness-shire. At that time he was living at Raits, near Kingussie, a little family estate, and was there putting into practice some of the experience and knowledge of land management and farming which he had gained in England and France, and from his study of classical writers on agriculture. Rows of elms planted by him along the line of Wade's military road there are mentioned in the *Old Statistical Account of Inverness-shire.*

But his devotion to agriculture and forestry was less strong than his political convictions, and in the autumn of 1714 we find him specially active in the interests of James the Pretender. A letter found among the Montrose papers, and dated 24th September

of that year, states that "Mr William Mackintosh of Borlum, who has come in March from Bar-le-Duc,[1] is traversing the country from west to east, and hath persuaded the Laird of Mackintosh to join the Pretender's cause."

On 6th September 1715 the Earl of Mar raised the standard of James at Braemar, and on the 13th of the same month the Mackintosh, spurred on by his kinsman of Borlum, "conveened his men, as was given out, to review them, but in the evening he marched straight to Inverness where he came by sunrise with colours flying, and after he had made himself master of what arms and ammunition he could find and some little money that belonged to the publick, proceeded to proclaim the Pretender King."

Borlum, as he was then known, though his father was still alive, was undoubtedly the moving spirit in this enterprise.

From Inverness his Chief and he, with about seven hundred followers, marched south to Perth and there joined the Earl of Mar. The Mackintoshes, under their Chief, became the Mackintosh Battalion, and this, with five other regiments, formed a brigade, the command of which Mar gave to Borlum. As Brigadier-General, with about 2500 men under him, he was sent off to the south country to stir up and help the Jacobites on both sides of the Border. Slipping past the King's forces, he hastened through Fife to the shores of the Firth of Forth. Three warships patrolled the waters of the Firth, guarding the passage, but Borlum secretly collected a number of boats at Crail, Pittenweem, and elsewhere, and managed to transport to the southern shore about 1500 of his men, including the Mackintosh Battalion, with the loss of one boat-load of forty men captured. Gathering his force at Haddington and Tranent he marched on Edinburgh, hoping to capture the city by surprise. But he was forestalled by a rapid concentration of royal troops, whereupon he turned aside to Leith and took possession of the old Cromwellian fort there. Argyll, the Royalist commander, with a strong force laid siege to it, and Borlum, recognising the hopelessness of trying to hold out, promptly made off eastward. At Seton House he received orders from the Earl of Mar to proceed south and join up with Lord Kenmure and Mr Forster. His rapid march to Dumfries must have made a deep impression on the minds of the people in the Border counties, for Sir William Chambers tells us that in his boyhood, almost a hundred years later, school-children at Peebles used now and again "to bombard with stones a grievously defaced effigy built into the walls of a ruinous old church in the neighbourhood. With savage significance the unfortunate piece of sculpture was called 'Borlum,' and as Borlum it had been pelted for several generations," although it had really no connection with that valiant Jacobite.

At Dumfries Lord Kenmure pressed for an advance into England. Mackintosh wanted to join the West Highland Jacobites under

[1] The residence of the exiled Stuarts in France.

General Gordon, but he was overruled. Many of his Highland followers refused to leave Scotland and turned north again, and Borlum is described as standing in the middle of the River Esk striving to prevent their desertion.

The rising in the north of England was a dismal failure, largely on account of dissensions among the leaders, and at Preston, on 16th November 1715, the rebels surrendered to General Carpenter at discretion.

Mackintosh was strongly averse to surrender, but he was taken prisoner with the others. Many of the rebels were executed and many were sent as slaves to the plantations. Mackintosh and his son were imprisoned in Newgate Gaol in London. A fellow-prisoner was General Forster, and it was said to be a common entertainment with frequenters of the gaol to listen to Mackintosh and Forster quarrelling violently about the conduct of the campaign which had failed so miserably.

On 4th May 1716 Mackintosh, his son, and several of their fellow-prisoners attacked the turnkeys and the sentinels and broke out of prison, the Mackintoshes managing to escape to France. A handbill issued by the Corporation of London offered £200 for his recapture, and to this the Government added £1000. The handbill describes Borlum as " a tall, raw-boned man about sixty, fair complexioned, beetle-browed, grey-eyed, speaking with a broad Scotch accent."

The prison-breaking feat was commemorated in a broadsheet of the time :—

> Brave Derwentwater he is dead;
> From his fair body they took the head;
> But Mackintosh and his friends are fled,
> And they'll set the hat on another head.
>
> And whether they're gone beyond the sea
> Or if they abide in this countree,
> Though our King would give ten thousand pound
> Old Mackintosh will scorn to be found.

While an exile in France Mackintosh became the laird of Borlum, his father having died in 1716. He was back in Scotland in 1719, when he took part in another abortive Jacobite rising. Six thousand men set out from Spain to come to Scotland, but only three hundred, mainly Spaniards, reached the island of Lewis, where they were joined by Lord Tullibardine, the Earl Marischal, and Lord Seaforth. The small force landed on the mainland, but after an indecisive skirmish in Glenshiel the effort collapsed. Mackintosh, who had again taken an active part, had to go into hiding. He was eventually captured in the wilds of Caithness, and was sent as a State prisoner to Edinburgh Castle, where, after a long period of imprisonment, variously stated at from fifteen to over twenty years, he died on 7th January 1743, at the age of eighty.

He held stoutly to his Jacobite principles to the end, and one of his last acts is said to have been to scratch, with one of his teeth, on the wall of his cell, "God bless King James." The *Caledonian Mercury*, in noticing his death, speaks of him as "a complete gentleman, friendly, agreeable, and courteous, and a lover of his country."

It was indeed under that cognomen, "A Lover of his Country," that he issued the book and the pamphlet which entitle him to be ranked as an early improver of Scottish agriculture.

The book is called *An Essay on Ways and Means for Inclosing, Fallowing, Planting, etc., Scotland, and that in Sixteen Years at farthest.* It was published in Edinburgh in 1729, early in his period of imprisonment in the Castle.

He addresses his plea for improvement to the Members of the united Houses of Parliament, and begs them to take measures to carry out his proposals, even against the opposition they are sure to meet with, both from the Scottish landowners, who do not wish to lose the hereditary services of their tenants without recompense, and from the tenants themselves, who are ignorant and prejudiced. To the Members of Parliament he says—somewhat ironically, one imagines—"You are our Legislature: you know better what is good for us than we ourselves: ye cramb down upon us every Session Physick not very agreeable to our Taste because you know it is useful, yea necessary, to take it."

And he claims that he himself writes as "a private country gentleman and mere Colonus who never employed himself but in the improvement of his little hereditary grounds and pursuing the Game the Fields, Forests, and Rivers offered—a true Scotsman and a zealous lover of his country, who writes because the Spirit moves me."

In support of his plea for improvement he gives an interesting list of Scottish landowners who had already begun to show a good example in inclosing, planting, and fallowing. Chief credit, he says, should go to the Duchess of Gordon, daughter of the gallant Peterborough She had been useful not only in introducing proper fallowing, "but in all points of husbandry, economy, and ornament of our country, putting her neighbourhood in the right method of making hay, planting their muirs, laying out their grounds for gardening, and altering old houses." The example of the Duchess had prevailed with several gentlemen in the northern shires to enclose, to drain, and to plant their grounds, and even to sow French grasses. Sir Robert Gordon of Gordonstoun, Mr Dunbar, Sir William Gordon of Invergordon, and General Ross of Balnagowan are all mentioned as imitators of the noble lady, while in other parts of the country similar action is attributed to Mr Scot of Scotstarbat, Master Hope of Rankeillor, Sir Francis Kinloch, Colonel Chartres, Sir John Dalrymple of Edmonstone, Sir James Dick of Priestfield, Sir James Stewart of Goodtrees, the Duchess of Buccleuch, and others. Among these some had begun to sow rape

and turnips, and some to enclose fields with very good walls of stone and lime.

With the backing of these notables our author argues that improvement is not possible without enclosure, and thereupon proceeds to give a detailed technical description of the layout of enclosures according to the size of field desired. Stone and lime being too costly for general adoption, he advises that the fencing should be quickset hedge with ditch, as being best, cheapest, and most ornamental.

Recognising that Scotland is not a rich country, he then considers " ways and means to raise funds sufficient to prosecute Inclosing the Nation, and finish in a few years that useful and glorious design."

For the landlord he estimates the cost to be one-fifth of his rental annually for four years ; in other words, merely such a tax as was levied at the beginning of King William's reign to carry on the Dutch war against the French, and whereas all the produce of that tax was spent abroad, the money for enclosure would all be spent at home in the betterment of the landlord's own property. Or again, the cost would be less than the expense of a nobleman or gentleman's visit to London : let them stay at home and spend their travel money on enclosing for the four years necessary to complete it. For enclosing will more benefit the nation than the discovery of America did Spain. It would indeed pay the State to assist in financing enclosure, inasmuch as the value of the land would be doubled in a few years, and accordingly its taxable capacity would be so much greater.

As for the tenants, when asked to give their labour in enclosing, the writer expects them to say, " Have we not enough to do already in service to landlords and in our own behalf ? " He therefore makes a strong appeal for the abolition of these old feudal services. He avers that the Commons of Scotland were cajoled into acquiescing in the Union by the hope that they would be freed from superiority and heritable jurisdictions, and put on a level with the English. To induce the tenants to undertake the work of enclosure he suggests first, that nineteen-year leases be granted ; second, that during a lease the tenant shall be free of all manner of service to his landlord. full rent, customs, and kains in money, victual, etc., to be paid as hitherto, but no work either of his person, servants, or bestial to be exacted, save only the carrying home of fuel. The time needed to be given to the work of enclosing will be less than that formerly given to the service of the landlord, and it will now be spent for the tenant's own benefit. His corn will be secure without the cost of herding it, and his stubble will be his own, not common grazing. The tenant is not asked to lay out money, only to give labour ; and it is considered that a farmer and three men should, in twenty-six to thirty days, be able to do all that is necessary to enclose ten acres.

The holder will be amply repaid by the increased milk yield of his

cows alone. These will not be chased about by careless herds, but will lie at peace in the warm sheltered closes, and will have the advantage of being shifted often to fresh, clean grass; while, if the enclosed fields are cropped, with fallowing and summer ploughing introduced, and a proper rotation followed, the resulting return will be ever so much greater than before.

Here the writer realises the need for educating the farmer if he is to be made receptive of new ideas. He accordingly proposes the establishment of a College of Agriculture, manned by agriculturists who had gained their knowledge from practical experimental work rather than from books. "I affirm," he says, "such a College would prove of more real value and solid use to the Island to have it established in some if not all of our Universities than many of these the munificence of several princes and many other well-meaning persons have endowed with large revenues to teach other sciences." This proposal to institute a seminary of agriculture in Scotland is not an airy notion, but is founded on similar ideas from the classical writers. Sir Francis Bacon and Abraham Cowley had both proposed this for England, and that country needed it much less than Scotland.

The author goes still further, and suggests the inclusion of agricultural teaching in the curriculum for ordinary schools, and he shows refreshing candour in deprecating the giving of classical and University education to many sons of tradesmen and farmers not really fitted for it. He is all in favour of leaving the door open to the lad o' pairts, but he asserts strongly that skilful husbandmen and artisans are more useful to the nation than mediocre philosophers or scholars. Nor would he restrict the teaching of agriculture to boys born to be farmers or farm-workers: he would extend it to the youth in all schools, public and private, and especially to the sons of noblemen and gentlemen who will later have estates in their trust. Such agricultural instruction need not interfere with their classical education, for there are Greek and Latin writers on agriculture whose works are more worthy of study than those of Ovid or others now in use in the schools.

It is not possible to notice at length all the suggestions for improvement which occur in the treatise, but brief mention may be made of some of them. Thus, the planting of apples, pears, and plums is advocated. The keeping of swine should be developed: they are very useful but very ill-kept in Scotland. The supply of beef and mutton falls far short of the demand: even Edinburgh has practically no fresh meat for more than half the year; the farmer ought therefore to set himself to provide what is wanted: he should grow turnips, rape, hay, and foggage for winter feed, and he is given instructions for getting a suitable tilth for turnips and rape—crops with which few Scottish farmers were then acquainted. A method of bringing rundown land into good heart is set forth, this being the sowing of "new outlandish grass seeds," and feeding cattle on it for

some years before taking a crop. The practice of dividing up fields by movable fences is recommended, so that cattle or sheep grazing or feeding on turnips or rape may make the greatest use of the crop. Earlier sowing than was then the custom is urged, and the advantages to be gained are enumerated.

In order to secure the widest possible support for his proposals of improvement, the author appeals successively to the clergy, doctors, lawyers, and University professors, and to each group he shows special reasons why their help should be given.

He begs the clergy to explain to their parishioners the reasons for enclosing, and likewise to set the example by enclosing their own glebes and demonstrating thereon, as far as possible, the new methods of farming. One inducement to the clergy is worth noticing. "For sure when the weather is fair their little Manse-houses are not so fit for their studies as these delightful enclosures under a Hedge are. There they don't hear nor are disturbed nor diverted by Children's crying, the Mistress and Servants speaking loud about their little domestic affairs, from which Noise no room in his House is remote enough."

The writer welcomes the recent appointment of the Board of Trustees for the encouragement of Linen Manufacture and of Sea Fisheries in Scotland, and he points out that the first step towards improvement in the production of linen is to encourage enclosure. He suggests also that proper flax seed should be supplied to the growers, and that right methods of cultivation should be demonstrated to them.

So far as the fishing industry is concerned, the best way to develop it is to create a demand for its produce by a people made prosperous through improved agriculture. As Defoe says in his *Caledonia*:

> With Wealth and People happy, rich, and free
> You'd first improve the Land and then the Sea.

The Trustees ought therefore to exercise their influence in securing legislation in the United Parliament to make enclosure compulsory, to make nineteen-year leases obligatory, and to discharge all feudal services except the one before mentioned. They ought thereafter to appoint County Committees with supervisors and gaugers to see that enclosures are being duly carried out, and also to import from England skilled hedgers and ploughmen and drainers—about twenty for each county—to train the Scottish labourers in their arts.

"If the Honourable Trustees will bring that great Reform about, the Folds shall be full of Sheep, the Valleys also shall stand so thick with Corn that they shall laugh and sing."

Mackintosh's second publication is entitled *An Essay on the Husbandry of Scotland, with a Proposal for the further Improvement thereof.* By a Lover of his Country. Printed and to be

sold at Mr Dunning's Shop and by other Booksellers in Town. MDCCXXXII. Price Threepence.

It is a less ambitious publication than the other, and it may indeed be regarded as a supplement to that work.

The author now emphasises that the main benefit of proper fallowing is the cleaning and mellowing of the land. If therefore this can be secured without the loss of a season's crop, then we have a further advantage, and he goes on to show that the newest procedure is to substitute a turnip crop for the fallow, when the same effect is produced. The explanation of this he alleges to be the existence of two classes of plants—(1) those which the earth produces willingly, and (2) those which require forcing by dung, etc., and which tend to exhaust the soil.

The former include pease, pulse and all legumes, "which, probably by sheltering the ground by the broadness of their leaves, make it retain the Nitre and Spirit of the air and thereby enrich it." A wonderful forecast of a later scientific discovery!

Of the second sort are wheat, bere, rye, and oats, "all peelers of the ground."

It is not the rest that fallowing gives the ground that is important: it is the cleaning of the land and the impregnating it with juices that are fit for the production of plants, and "Turnip has the same effect to a greater degree: for if they take well and be fed on the ground, they will, beside the great benefit the cattle get by them, be better to the land than both Fallowing and dunging"—as then practised.

It is bad husbandry, then, to take two crops of any of the robbing grains successively, and yet it is the prevailing custom in Scottish farming.

For an example of legumes enriching the soil he quotes a personal observation. A field was sown with ryegrass and clover, but one ridge was missed in sowing the grass, getting clover only. It was better grass after the first year than the rest of the field, and when the field came to be ploughed up it was remarkable to see how much that ridge which was sown with clover alone was better corn than the rest, the clover having enriched it and the ryegrass "peeled" the other part of the field.

He accordingly proposes that we ought to cleanse our ground every fourth year by turnip instead of fallow, and make pease the intermediate of the three following crops. Turnips, he declares, can be grown in every county in Scotland, and they will be very profitable for winter feed to cattle kept in grass districts, such as Galloway. The Earl of Stair had indeed already introduced the turnip crop in that county with advantage. In their cultivation the author recommends the use of the drill plough.

From the point of view of labour management he advocates the four-shift rotation as distributing field work better over the year.

For spring feed for sheep and cattle he suggests the growing of

winter vetches, to be followed by a turnip crop. This method of farming he has seen in use in Flanders, where it is very profitable. It is an excellent practice also to dung the grass: this makes it spring all through the winter, lengthens the growing season, increases the quantity, and improves the quality. The perpetual verdure noticed on old pastures, town greens, and places where sheep have lain is not due to the age of the grass, as people commonly imagine, but to the dung in which these places abound. The same will happen to grounds laid down to grass but lately, provided they are well dunged.

What strikes one most in reading these writings of the old Jacobite is the modernity of their note. But for the faded print and the quaintness of phraseology and spelling, it is difficult to realise that they date back more than two hundred years. In better conditions and more peaceful times his restless energy and his bold initiative, his wide knowledge, both practical and academic, and his scientific bent of mind, together with his love of the land and his ardent patriotism, would have made William Mackintosh of Borlum a great national leader and a benefactor of his country.

EXPERIMENTS ON LAWNS

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In recent years a considerable amount of attention has been directed to the improvement of lawns, and experimental work has been conducted at Craibstone with a view to determining the most suitable grasses and mixtures for sowing. Several points in connection with the manuring have been dealt with also, and these are described in the following article.

The soil is light and liable to dry up after dry weather in summer, and this must be kept in mind when considering the results of the trials, as the same result might not be obtained on other classes of soil.

The first trial dealing with grasses was started in the spring of 1928, when plots were sown at the rate of ½ oz. per square yard with the following grasses :—

Plot 1. South German bentgrass.
,, 2. Crested dogstail
,, 3. Perennial ryegrass.
,, 4. Chewings fescue.
,, 5. Smooth-stalked meadowgrass.

Plots 1 and 4 brairded quickly and in a short time became very thick, and except for some white clover which came in naturally

have remained very clean and free from weeds, but the latter plot during the winter months turns withered looking, while the former also loses its fresh appearance. Plots 2 and 3 have remained somewhat open, although a considerable amount of annual meadowgrass has filled up many of the openings. Plot 5 has all along been a total failure and is now mainly composed of annual meadowgrass and white clover.

Mixtures with different quantities of these grasses were sown at the same time as follows :—

	Per square yard			
	Plot 1	2	3	4
Bentgrass	$\frac{1}{6}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{4}$
Crested dogstail	$\frac{1}{15}$	$\frac{1}{15}$	$\frac{1}{15}$	..
Perennial ryegrass	..	$\frac{1}{10}$	$\frac{1}{15}$	..
Smooth-stalked meadowgrass	$\frac{1}{15}$	$\frac{1}{15}$	..	..
Chewings red fescue	$\frac{1}{6}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{4}$

Plot 4 has all along been best and closest, having a good mixture of the two grasses with very few weeds of any kind, but latterly some white clover has made its appearance. The other plots have been quite good and close but are rather rougher, owing to the larger plants present.

In the spring of 1930 plots with different kinds of bentgrass, fescues, and ryegrasses were sown as follows :—

Bentgrasses	Sheeps Fescues
1. American (fiorin).	1. Fine-leaved.
2. Kent.	2. Sheeps.
3. New Zealand (2 samples).	3. Hard.
4. South German.	4. Chewings red.
	5. German red.

Ryegrasses

1. Ayrshire.
2. Late-flowering evergreen.

The plants of the American fiorin have been very rough, with large, broad leaf blades ; the plot has never closed up at all and has filled up mainly with annual meadowgrass. The Kent, New Zealand, and South German bentgrasses, on the other hand, have all closed up well and become quite thick. One of the New Zealand samples has kept greener than the others during winter.

The individual plants of the fine-leaved, the sheeps, and the hard fescues have all along been quite easily seen, due to their tufty habit of growth, and none of them has ever been at all attractive, although the first has closed up quite well, while the hard fescue plot has been far too rough.

The plants of the German red fescue were stronger than those of

Chewings and the plot has therefore been hardly so fine, although it has remained greener during winter.

The ordinary commercial perennial ryegrass has been opener than the evergreen, but both have been rather rough, the comparatively long leaf blades being soft and succulent during the growing season. The open nature of the former has enabled more annual meadowgrass to become established. So far, moss has not appeared in any of these plots.

Several plots were sown at the beginning of August 1931, mainly with different samples of bentgrasses and fescues. The weather was dry and the plots all brairded very thinly, and even in the spring of 1932 none of them looked well although all were quite clean. In April an application of sulphate of ammonia at the rate of ½ oz. per square yard, fortunately followed by some rain soon after, encouraged the grasses so much that the plots soon thickened up, and in autumn most of them were extremely good, with few weeds or annual meadowgrass.

Notes dealing with the individual grasses used in the trial are appended.

Bentgrass.—These included four samples of New Zealand and two of South German. While all were thick, three of the former were greener than the others during the winter months.

In three small plots, pieces of plants of ordinary bentgrass, Borth's bentgrass and dog's bentgrass were planted four inches apart each way at the same time as the seeds in the trial were sown. The pieces gradually spread out and now they have completely filled the ground. The Borth's has kept greener than the others, not only during winter but also during the past extremely dry summer. This grass grows very slowly so that little cutting is required; but unfortunately no seeds of it can be obtained, and it must be reproduced vegetatively.

Fescues.—Of three samples said to be German red fescue, one was hard fescue, while the leaf blades of the other two were rather rougher than two samples of Chewings fescue alongside. The latter, however, had a more withered appearance during winter. The plots of fine-leaved and hard fescues filled up well, but they have never had an attractive appearance, while the leaf blades of the latter are far too thick and rough to be suitable for a lawn.

Crested Dogstail.—Although the plot with crested dogstail was thicker than in the previous trial and kept greener during winter, the leaf blades are too strong to make an attractive lawn.

Perennial Ryegrass.—The most outstanding feature of a plot with evergreen perennial ryegrass was its remarkably green colour during the winter and spring months. It was not, however, so pleasing during summer.

Smooth-stalked Meadowgrass.—A plot with smooth-stalked meadowgrass was no better than in a previous trial, and filled up with annual meadowgrass.

In an attempt to get some information regarding the correct amount of seed of these lawn grasses to be sown, plots of South German bentgrass, New Zealand bentgrass, Chewings fescue and a mixture in equal proportion of the last two, were sown at the beginning of August 1932, at the rates of 100, 150, and 200 lb. per acre (equal to about $\frac{1}{3}$ oz., $\frac{1}{2}$ oz., and $\frac{2}{3}$ oz. per square yard). A fairly heavy rain fell within two days after sowing, followed by a further fall in a few days. The temperature of the soil at this time was about 55° F. There was a strong and uniform braird in little more than a week, and at the beginning of September the plots were all thick and looked as if they had been sown for some time. Under such ideal conditions, when practically every seed grew, the plots with the smallest amount of seed were quite as good as those with the largest amounts, and at the present time one cannot distinguish between the plots.

The trial shows distinctly that no definite statement can be made as to the amount of seed to sow, as the conditions after sowing are liable to vary greatly. Where the moisture conditions are not too good, and when a proportion of the seeds consequently do not come, a rather larger quantity than the thinnest seeding would be advisable. A thick seeding is also better able to prevent the entrance of weeds. It is a good plan to mix the seed four or five days before sowing with three or four times its bulk of slightly moist finely sifted soil.

For most purposes, a seeding $\frac{1}{3}$ to $\frac{1}{2}$ oz. per square yard of New Zealand bentgrass or a mixture of $\frac{1}{4}$ oz. New Zealand bentgrass and $\frac{1}{4}$ oz. Chewings fescue per square yard, if well sown out, should make a satisfactory lawn.

For those who do not require a very fine lawn and who do not object to white clover, a mixture of 20 parts of Kent evergreen perennial ryegrass, 10 parts New Zealand bentgrass, and 1 part wild white clover, sown at the rate of $\frac{1}{3}$ oz. per square yard, should make quite a good sward, as the presence of the white clover would keep the whole plot green.

Manurial Trials.—In applying manures of any kind, consideration must be paid to what is already in the soil, as one may inadvertently apply what is present in abundance.

Manures are usually used on lawns for three different purposes, and their value must be judged from their effect so far as these are concerned :—

(1) To improve the general appearance of the lawn.

(2) To kill weeds, especially daisies and plantains, and also white clover.

(3) To prevent the entrance of moss.

Plots with different manures were laid down in the spring of 1929 on the alley that had been sown the previous year with a mixture of bentgrass and Chewings fescue. It was in good order for such a trial, as it was uniformly covered with a fine mixture of the two grasses and was quite clean except for a few hawkweeds, which were

taken out. The quantities of manures applied per square yard (one dressing per annum) were as follows :—

Plot 1. No Manure.
,, 2. Complete Manure :
{1 oz. Sulphate of Ammonia
2 ,, Superphosphate.
1 ,, Muriate of Potash.
,, 3. As plot 2 but No Nitrogen.
,, 4. ,, ,, ,, No Phosphate
,, 5. ,, ,, ,, No Potash.
,, 6. Nitrogen only.
,, 7. Phosphate only.
,, 8. Potash only.
,, 9. No Manure.
,, 10. 2 oz. Sulphate of Ammonia.

The sulphate of ammonia, whether alone or in mixture, had the greatest effect. A day or two after it was applied the grasses became green and remained so for ten or twelve weeks. Afterwards, however, they lost colour, and during winter they were more withered in appearance than where no sulphate of ammonia had been applied. Each successive application had the same effect but in a more marked degree. At first the double sulphate of ammonia plot showed up extremely well, but it also became more withered during winter and this has become more pronounced each winter. During the past dry summer this plot was almost burned up, and further reference to this point will be made later. Soon white clover began to appear in the other plots, and during the winter months moss also appeared. No. 3 plot (phosphates and potash) has now most white clover and has remained green during the winter months, no doubt due to the nitrogen supplied by the white clover. The second best growth of white clover is in No. 7 plot (phosphates alone), which is also fairly green. During winter most moss is present in No. 8 plot (potash only), while the no manure plots come next in order in this respect. The phosphates and potash and the phosphates only plots have only a little, while on those with sulphate of ammonia there has hardly been any moss at any time.

A similar trial was started in 1931. In this case, however, only half of the nitrogen plots got sulphate of ammonia, the other half getting an equivalent amount (1⅓ oz. per square yard) of nitrate of soda. When the trial started there were a few daisies present, while there was also a fair covering of white clover and during winter a small amount of moss which, however, disappeared during summer.

The nitrogen killed the daisies and the white clover, while the phosphates and potash, especially the former, encouraged and further developed the white clover. The side that got nitrate of soda produced a quicker growth of grass which, however, was far too soft and succulent and consequently more difficult to cut.

In the following two years sulphate of ammonia was used on both sides of the plots, but it is interesting to note that the effect of nitrate of soda was quite distinct during the summer months of both 1932 and 1933, the grass coming quicker and being of a lighter colour.

During the winter months the moss was quite prominent on the side where nitrate had been used, while it was almost absent on the sulphate of ammonia side. The plots with phosphates had also less moss, while the potash plots and those with no manure had most.

In April 1932 an alley which was well covered with daisies, plantains and white clover, but with very little appearance of grass, was laid off into twelve plots. Six of these got a dressing of 1 oz. sulphate of ammonia per square yard, followed by two similar dressings at intervals of about one month. The result was that practically all the daisy, plantain, and white clover plants were burned up and the grass was so much encouraged that it soon filled up the vacant spots.

During the early winter there was a considerable number of worm casts on the untreated plots whereas there were hardly any on the treated, probably because the soil of the treated plots was drier.

In this and other trials the sulphate of ammonia was applied under different conditions and it was found that it had the greatest effect on the weeds and white clover when applied in the morning when there was dew on the grass, and especially when bright sunshine followed. When applied immediately after cutting the grass it had an injurious effect.

In another trial carried out this year (1933) four applications of 1 oz. per square yard of sulphate of ammonia were made within a fortnight, care being taken to see that there was dew on the grass at each application, and the result again was that every white clover plant, daisy, and plantain, as well as a few self heals, were killed out, and within a short time the grass came up thick and dark green. It was noticeable, however, that the treatment did not injure buttercups. In still another trial where two dressings of 2 oz. each were applied within a week, these weeds were killed out.

In the autumn of 1932 several plots on one of the alleys were treated with 1 oz. per square yard of sulphate of ammonia to see whether this would make the grass greener during winter. The sulphate of ammonia was sown on the following dates :—

Plot 1.	1st Sept.	Plot 4.	1st and 16th Oct.
,, 2.	1st and 16th Sept.	,, 5.	1st Nov.
,, 3.	1st Oct.	,, 6.	1st and 16th Nov.

Untreated plots were left between each of these. When the first plots were treated there was little appearance of moss, but it was showing clearly on the untreated plots about the beginning of November. The result was remarkable. There was no moss at any time during the winter in the first four plots and only a little on the last two, whereas in all the untreated plots it came up so thick that the grass

could hardly be seen. Further, the grass on the treated plots, especially those which had double doses, kept green during the whole winter and well into the summer months. The early treated plots were best during winter, but the late treated were best in spring and remained green longer in summer.

A similar trial was laid down this autumn (1933) and the result so far as the moss is concerned is as remarkable as in the previous trial, but the September dressings, especially the double dose, burned the grass somewhat, owing no doubt to the extremely dry condition of the soil at that time.

In the plots treated in October, and even in November, the grass became quite green all over, there being little burning effect.

A trial was started in 1931 on an alley which was fairly free from weeds but on which was some white clover, with different nitrogenous manures, equivalent amounts of nitrogen to 1 oz. per square yard of sulphate of ammonia being used. One application was made each year. The trial showed that where nitrates (nitrate of ammonia, nitrate of soda, nitrate of lime, and nitrochalk) were applied, the grass grew quicker than with sulphate of ammonia. It was consequently more succulent and more difficult to cut. They all tended to encourage moss but did not dry up so much during summer. Chloride of ammonia had much the same effect as sulphate of ammonia.

A trial was also started this year with blood meal and cotton-seed meal as representing the organic type of nitrogen, but so far it cannot be said that they have showed any good effect. On several occasions sulphate of iron has been tried alone (½ oz. per square yard) and also along with sulphate of ammonia (these two and sand are usually the ingredients in lawn sand) and superphosphate. It helped to destroy weeds like daisies and kill out moss, but it had no effect on white clover. In one case there was a very thick coating of moss, which was very heavily raked and partly removed before an application of sulphate of iron and sulphate of ammonia was made. This treatment killed out most of the remaining moss and so encouraged the grass that a good lawn was the result. Sulphate of iron is apparently best for killing moss, and sulphate of ammonia for preventing it. The sulphate of iron, however, has the effect of leaving the whole lawn black and unsightly for a time.

One other trial was made with old, well-rotted dung which was dried and sifted and spread on a lawn that had become very grey. Although the lawn was rather unsightly for a time, it ultimately became very fresh and green and remained so for a considerable time.

These results show that nitrogen is by far the most important manurial ingredient for a lawn, and sulphate of ammonia generally the best nitrogenous manure. When the conditions are suitable, it kills out white clover and prevents the entrance of moss, and for some time after an application the grass remains fresh and green.

There is the difficulty, however, that the better the early results are from dressings with sulphate of ammonia, the greater may be the reaction and the poorer the after result. The treatment apparently causes naturally dry soil to dry up so completely during the summer months that the grasses actually wither and shrivel up, and the more sulphate of ammonia used the worse is the effect. This also appears to be cumulative, as the drying effect was worst where sulphate of ammonia had been applied in the largest quantities for several years. Thus on the plot where 2 oz. per square yard had been applied for four years, the soil was as dry as dust at the end of the last summer, whereas on plots alongside that did not receive sulphate of ammonia the soil was reasonably moist.

In a field of ordinary pasture where there is a mixture of grasses and clovers, white clover, once it becomes established, supplies all the nitrogen that the grasses require—certainly equal to several cwt. per acre per annum of a nitrogenous manure. The field consequently will remain green throughout the whole year and is not nearly so liable to dry up as where there is little or no white clover. In a lawn where white clover is not required a nitrogenous manure must be applied.

The use of sulphate of ammonia is dependent on the moisture supply; there must always be sufficient moisture in the soil before an application of sulphate of ammonia is made, otherwise disaster will inevitably follow. Any watering required must be done long before the soil is dry. The dry summer of 1933 brought out the weak parts in this respect. It was very noticeable that round the edges of the plots where the roots of the plants could spread out and so obtain sufficient moisture, the plants were quite fresh and green, whereas in the centre of the plots the plants withered.

A complaint was received regarding part of a lawn that was burning up while the remainder was quite green. When it was examined it was found that the soil of the burned-up part was almost pure sand and dust dry, whereas the soil on the other parts was quite a good loam. The explanation apparently was that a heap of sand had been left by the builder on this spot, and when the lawn was made, this sand had not been well spread out and mixed with the good soil. It is essential in laying out a lawn to have both the soil and the subsoil uniform throughout to ensure a satisfactory result.

Conclusions :—

1. The ingredient most necessary is water, and no manurial treatment should be given unless the soil is sufficiently moist.
2. The most important manurial ingredient is nitrogen.
3. Sulphate of ammonia is the most suitable nitrogenous manure. It kills daisies, white clover, etc., and prevents the entrance of moss. Normally, two dressings each of 1 oz. per square

yard, at intervals of three or four weeks in spring, and other two dressings in September or October will suffice.

4. Superphosphate with sulphate of ammonia also helps to keep out moss. Along with one of the autumn dressings of sulphate of ammonia, 1 oz. per square yard of superphosphate may be applied yearly.
5. Sulphate of iron kills weeds and moss but leaves the lawn black for some time. ½ oz. per square yard along with sulphate of ammonia may be applied in spring where moss is present.

COLIFORM BACTERIA IN MILK

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THE coliform or colon bacteria are, as the name implies, normal inhabitants of the large bowel or colon of man and most other animals, including birds and fishes. Not only are they the most prevalent organisms in the intestines of adults, but also in the excreta. They are frequently found in natural water supplies, the numbers being much greater where there has been contamination with sewage, animal excrements and surface drainage from farmyards and fields. They also occur to some extent in the soil, especially that treated with farmyard manure; and on fodder, silage, and cereal grains. They are frequently present in milk and its products as a result of contamination with excreta and other materials.

The coliform bacteria comprise a large and important group of organisms, closely related to the typhoid, para-typhoid, and dysentery bacteria, but unlike these organisms they have generally little or no power of causing disease. Like other intestinal bacteria they grow best at bloodheat, about 98° F. or 100° F. They are non-sporing, and consequently when present in milk can be destroyed by pasteurisation. They have a marked ability to decompose various sugars, but with a few exceptions are unable to attack proteins such as gelatin and casein. Accordingly when present in milk they ferment the milk sugar or lactose with production of acid and gas, but do not digest the casein.

Coliform bacteria frequently occur in milk and its products. In an investigation carried out by the Bacteriology Department of The West of Scotland Agricultural College the prevalence of coliform bacteria was determined in 21,569 samples of market milk, which in most instances were taken without warning over a period of several years from the milk supplies of individual farms as they were being weighed in the receiving tank at a creamery or dairy. They were therefore typical of the general supplies. Of the 21,569 samples, 48·3 per cent. did not contain coliform organisms in

1/10 c.c. and smaller amounts of the sample; 21·4 per cent. contained them in 1/10 c.c. but not in 1/100 c.c. and 1/1000 c.c.; 14·0 per cent. contained them in 1/10 c.c. and 1/100 c.c. but not in 1/1000 c.c., and 16·3 per cent. contained them in 1/10 c.c., 1/100 c.c. and 1/1000 c.c. It is probable that these results are better than those generally obtained from samples of ordinary farm milk, because all were tested within twenty-four hours and many within twelve hours of milking. Further, they were obtained mostly from creameries whose supplies had been submitted to such tests for a number of years.

Coliform organisms are much more prevalent in samples of milk during the warmer months of the year, as is evident from Table I and corresponding figure. These give the results of the tests of samples of milk from the same group of farms for a whole year.

TABLE I

The influence of season and temperature on the proportion of coliform positive samples[1] and on the bacterial content of samples of milk from the same group of farms.

Average number of samples per month 30

Month in which samples received	Average bacterial content per c.c.	Proportion of coliform positive samples, expressed as a percentage	Mean of the minimum and maximum atmospheric temperatures for the day on which samples received
January .	21,304	24·0	31·5
February .	33,179	35·5	41·0
March .	29,407	15·0	42·0
April . .	33,263	41·0	42·5
May . .	46,126	39·0	48·5
June . .	112,444	63·0	55·5
July . .	277,859	96·0	57·5
August .	252,431	91·0	57·0
September .	90,488	62·0	55·0
October .	26,131	47·0	45·5
November .	9,950	25·0	47·5
December .	11,764	24·0	39·5

The tests were made at monthly intervals; all the tests for one month were performed on the same day, and the mean of the minimum and maximum atmospheric temperatures estimated for that day. Although the table and figure give the results for only one group of farms, they are typical of those for other groups, and show that there is a definite positive association between the proportion of coliform positive samples and the mean of the minimum and maximum atmospheric temperatures. This is probably due largely to the influence of temperature on the rate of multiplication

[1] Samples containing coliform organisms in 1/10 c.c.

of the bacterial contaminants, both in milk which has not been cooled and in utensils which have not been properly sterilised.

Coliform bacteria are a great source of trouble and financial loss in dairying. It may be said that the greater the contamination of the milk with these organisms the lower generally is the quality and keeping property of the produce. They are frequently responsible, along with lactic bacteria, for the souring and curdling of market milk and cream, in which they produce unpleasant flavours and disagreeable aromas. The rate of acid production and amount of gas formed vary widely with different members of the group. The gas which is produced prior to curdling escapes from the milk and cream, perhaps the only evidence of its formation being a froth on the surface. After curdling occurs the gas is imprisoned in the curd and causes the curd to become spongy. If much of the gas has been formed before curdling there may be little evidence of it in the curd. The coliform curd differs greatly from that formed in the ripening of milk by the lactic or starter organisms. Not only does the former contain gas, but it is much firmer than the starter curd and shrinks to a great extent, so that much of the whey is expressed. Certain coliform bacteria are occasionally responsible for ropiness in milk, but this defect is most frequently due to other organisms. Cream undergoing coliform fermentation takes longer to churn, and the butter prepared from it is bad-flavoured and of low keeping quality. Milk heavily contaminated with coliform bacteria is not suitable for cheese-making, as the organisms will probably cause gassy fermentation, a common defect in curds and ripening cheeses. The latter may be so gassy that they bulge at the ends. Such hoven cheeses have frequently strong unpleasant flavours and odours and low keeping properties.

Apart from the fact that coliform organisms are frequently responsible for defects in dairy produce, they are of great hygienic importance. Their prevalence in milk is widely accepted as a reliable index of the extent of its contamination with extraneous bacteria and of the care taken on the farm to prevent such contamination. Little or no pathological significance, however, can as a rule be attached to their presence in dairy produce, apart from the fact that occasionally they are associated with cases of bovine mastitis (inflammation of the udder); but pathogenic organisms, *e.g.* those causing tuberculosis, mastitis, and typhoid fever, are not so liable to occur in milk from farms whose supplies are in most instances free from coliform bacteria. On such farms the better hygienic conditions and the greater care taken by the workers minimise the risk of spread of diseases, especially tuberculosis and mastitis, in the herds, while the milk is less liable to be infected from the workers themselves and from the water supply.

It was originally thought that the presence of coliform bacteria in milk indicated contamination with excreta. It is now recognised, however, that these organisms occur frequently in soil and on cereal

grains and fodder which have not been contaminated from human and animal sources. Consequently their presence in milk does not necessarily indicate fæcal contamination, especially if they occur in small numbers. But it is an established fact that fresh milk, produced with the utmost care and under good hygienic conditions, contains as a rule few or no coliform bacteria. If large numbers are present, it indicates that proper care has not been taken to prevent contamination, and in most instances the organisms will probably be of fæcal origin.

Coliform bacteria generally gain access to milk before it is removed from the byre. The following are the chief sources of contamination :—

(*a*) Excreta, soil, bedding, fodder, silage, and cereal grains. Milk is more readily contaminated if dried particles of dust from these materials are present in the air of the byre or on the skins of the cows.

(*b*) Unsterile utensils. If utensils are not washed thoroughly and sterilised after use they frequently become contaminated, especially during hot weather, with large numbers of coliform and other bacteria, owing to the growth and multiplication of these organisms in the milk residues. When the utensils are subsequently used the organisms gain access to the milk. It is a common practice on many farms to sterilise the utensils after morning use but not after evening use, and consequently in hot weather the morning milk is of a much lower standard of purity than the evening milk.

(*c*) The milkers. The milkers may not wash their hands before milking each animal, or after washing they may soil them by touching either dirty milking stools or dirty animals.

(*d*) The animals. Coliform bacteria are sometimes associated with cases of mastitis, but apart from this they seldom occur in the udder. They are frequently present at the openings of the teats and in the teat ducts, owing to contamination of these parts with excreta and dirt. They are therefore liable to be present in the fore or first-drawn milk. The presence of dung and dirt on the teats and other parts of the cows may also cause contamination of the milk.

(*e*) Flies. These may be responsible for contaminating the utensils and milk with excretal matter and dirt.

(*f*) The water used for washing the cows, the milkers' hands, and the utensils. This may be polluted with sewage, excreta, and surface drainage.

The presence of large numbers of coliform bacteria in milk kept for more than eight or twelve hours does not necessarily constitute evidence of its excessive contamination prior to removal from the byre. The high coliform count may be due to the fact that the milk, after removal from the byre, has come into contact with unsterile utensils, or has not been artificially cooled. Milk is a very

suitable medium for the growth of these bacteria. Provided the temperature is favourable, they multiply rapidly, a few organisms giving rise to millions within twelve hours. The optimum temperature for growth varies with different members of the group, but in most instances it is about 98° or 100° F. (bloodheat). They also grow fairly well at 70° F. and even 60° F., but fail to grow at temperatures below 50° F. The presence of large numbers of coliform bacteria in unpasteurised milk therefore indicates either excessive contamination in its production and handling, or failure to cool it early and keep it at a low temperature.

Coliform bacteria, being non-sporing, are readily destroyed by pasteurisation. They are, however, frequently present in pasteurised milk owing to faulty pasteurisation, contamination of the milk after heating, and occasionally to the occurrence of types which are extremely resistant to heat.

The *coliform test*, which is commonly employed to determine their prevalence in milk, involves the use of four tubes of a medium termed bile-salt lactose peptone water. The tubes are inoculated with 1 c.c., 1/10 c.c., 1/100 c.c., and 1/1000 c.c. respectively of the milk and incubated for 48 to 72 hours at 99° F. (37° C.). Owing to the presence of bile-salt only intestinal organisms can thrive in this medium, and the coliform bacteria are almost the only intestinal organisms that can ferment lactose with production of both acid and gas. Accordingly a positive coliform reaction is indicated by the presence of both acid and gas in the tube. If the tube inoculated with 1 c.c. of milk gives a positive reaction, it signifies that there is at least one coliform organism present per c.c. of milk. If the tube inoculated with 1/10 c.c. gives a positive reaction, it shows that at least 10 per c.c. are present, and so on, the smaller the amount of milk giving a positive reaction the greater being the extent of the contamination.

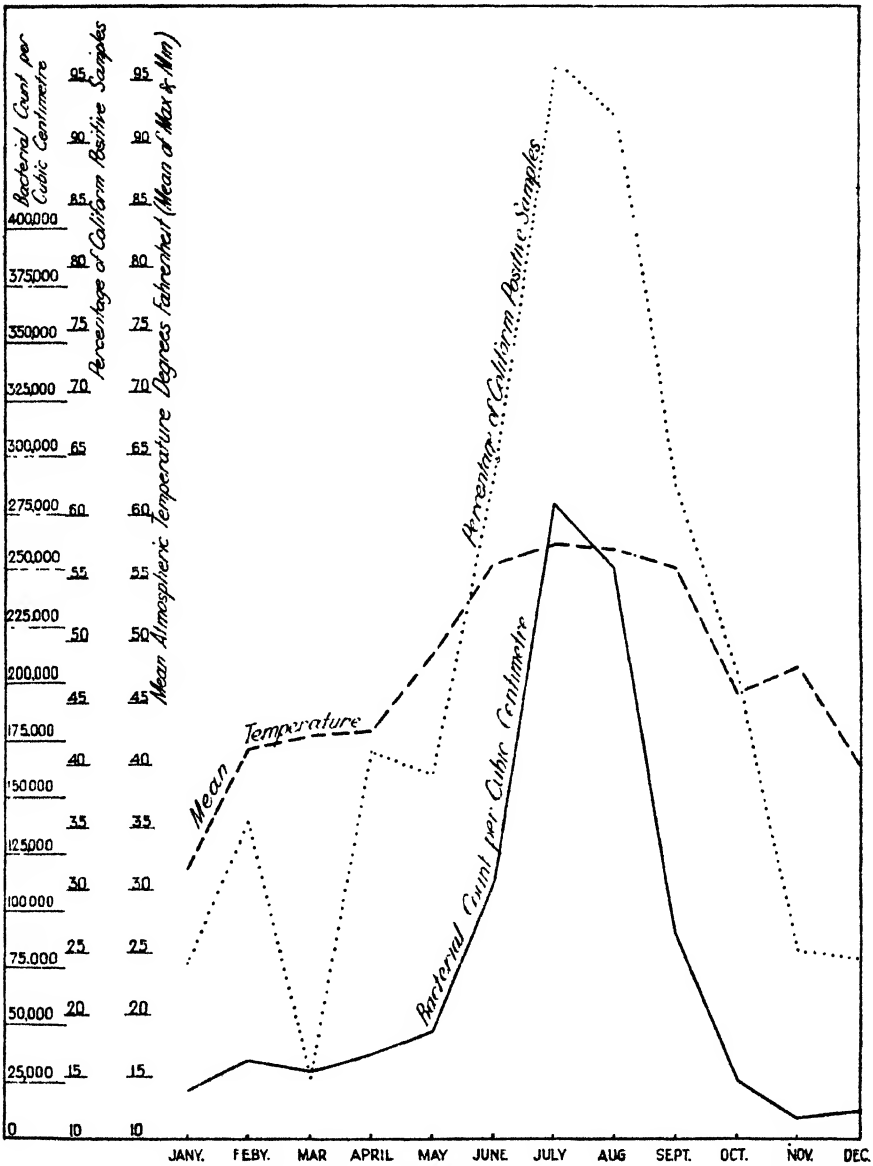
The coliform test is recognised to be of great value for the routine examination of samples of milk, and is widely used in Britain for this purpose along with the estimation of the total viable bacterial content. There may, however, be no definite association between the results of these tests, especially in the case of milk which has been kept only for a short period, as the contaminating substances vary widely, not only in regard to total bacterial content and coliform content, but also in the relative proportions of coliform and other kinds of bacteria present in them. Further, if milk is artificially cooled and kept at a low temperature, it may have a fairly low total bacterial content in spite of the fact that it has been contaminated to some extent with coliform organisms before its removal from the byre. It is consequently of importance that both tests be carried out.

As a rule, however, there is a marked association between the results of the two tests, samples containing coliform bacteria having generally a much higher total bacterial content than samples free

from them. For example, in an analysis of the results of the bacterial tests carried out by the Bacteriology Department on 21,857 samples of milk, estimations were made of the average total bacterial content of the samples which did not contain coliform organisms in 1/10 c.c. ("coliform negative") and of the samples which contained them in 1/10 c.c. ("coliform positive"); 10,458 samples were coliform negative and had an average total bacterial content of 25,294 per c.c., whereas 11,399 samples, which were coliform positive, had an average total bacterial content of 160,577 per c.c. The ratio of the average total bacterial content of the former to the latter was therefore 1 : 6·3. In other words, the coliform positive samples contained on an average 6·3 times as many bacteria of all kinds as the coliform negative samples. The higher total bacterial content of the coliform positive samples may be due to several factors, of which the following appear to be the most important: (1) a higher initial contamination of such milk not only with coliform bacteria but also with others, as a result of faulty methods and contaminated utensils, and (2) the multiplication of coliform and other bacteria in milk which is not artificially cooled to a low temperature. Samples of uncooled milk not only give in many instances coliform positive tests, but they generally contain large numbers of bacteria. It will be seen from Table I and corresponding figure that there is a well-marked direct association, as would be expected, between the proportion of coliform positive samples, the average total bacterial content, and the mean of the minimum and maximum atmospheric temperatures. This association appears to be due to the influence of higher temperatures both on milk which is not artificially cooled and on incompletely sterilised utensils, so that more rapid multiplication of contaminating organisms occurs. It must be borne in mind, however, that in the case of many farms maintaining even good conditions of cleanliness, the conditions at milking vary to some extent according to season. During winter the cows are confined to the byres and are supplied with food and bedding, while in summer they are at pasture and are given little or no house feeding and no bedding. Consequently in winter the atmosphere of the byres is generally contaminated to a greater extent with particles of fæces, food, and bedding. This increases the contamination of the milk during winter with coliform and other bacteria, and renders less apparent the association between bacterial content, prevalence of coliform organisms, and atmospheric temperature. On the other hand, during wet weather in summer milk may be highly contaminated owing to cows at pasture becoming heavily soiled with mud and fæces from fields and gateways. Further, cows at pasture, especially in early summer, suffer to a greater extent from diarrhoeal conditions than those confined to houses. Those two factors may be partly responsible for the higher total bacterial content and higher incidence of coliform organisms in milk during the summer.

There are three chief types of coliform bacteria : (1) the *Bacillus coli*, (2) the *Bacillus lactis aerogenes*, and (3) the *Bacillus cloacae*.

Graphic Representation of Table I.



Bacteria of the *Bacillus coli* type are the prevalent coliform organisms in human and animal fæces, and while they are frequently found in surface waters and the soil, they are present in such environment only in very small numbers, provided recent contamination

with fæces has not occurred. They are therefore commonly regarded as fæcal organisms. *Bacillus lactis aerogenes* and *Bacillus cloacae* types are the predominating coliform types in the soil and on plants and cereal grains; and in surface water provided there has been no recent pollution with fæces. They cannot, however, be regarded as being wholly of non-fæcal origin, as they occur in human and animal intestines and in fæces, though in comparatively small numbers in health.

In an investigation carried out by the Bacteriology Department of the types of coliform bacteria occurring in market milk, 359 strains were isolated from samples of farm milk during the winter and early spring ("the winter period"), when the cows were confined to the byres. Then an additional 438 strains were isolated during the summer and early autumn ("the summer period"), when the cows were at pasture for the whole or part of the day. The prevalence of the different types (expressed as a percentage) is given in Table II.

TABLE II

Prevalence of different types of coliform bacteria found in milk during a winter period (when cows were confined to the byres) and during a summer period (when cows were at pasture).

Type	Winter Period (Per cent.)	Summer Period (Per cent.)	Combined Periods (Per cent.)
1. B. coli	71·0	40·4	54·2
2. B. lactis aerogenes	7·5	22·4	15·7
3. B. cloacae	8·6	9·8	9·3
4. Intermediate	12·8	27·4	20·4

It will be seen that of all the strains isolated the greatest proportion (54·2 per cent.) belonged to the *Bacillus coli* type, while only 15·7 per cent. belonged to the *Bacillus lactis aerogenes* type and 9·3 per cent. to the *Bacillus cloacae*. Further, there was a much higher proportion of the *Bacillus coli* strains isolated from milk during the winter period than during the summer, 71·0 per cent. as compared with 40·4 per cent. In other words, in the winter the ratio of the *Bacillus coli* strains to those of the other coliform types was roughly 7 : 3 and in the summer 2 : 3. On the other hand, there was a much lower proportion of the *Bacillus lactis aerogenes* strains isolated during the winter than during the summer, 7·5 per cent. as compared with 22·4 per cent., while the proportion of *Bacillus cloacae* strains was approximately the same for both periods.

In considering the significance of the occurrence of the different types of coliform bacteria in milk the question of their origin is of importance. One might say that organisms of the *Bacillus coli* type are derived chiefly from bovine fæces, and their presence in milk may be taken as a reliable indication of fæcal contamination. Further, the greater preponderance of strains of this type during the

winter is in all probability due to the greater exposure of the milk to contamination with dung, when the cows are confined to the byres and not at pasture. As regards the strains of all the other types, in view of the uncertainty of their origin, their presence in milk is of no clear significance. They may have been derived from particles of fodder, bedding, soil, or even fæces. Further, one cannot suggest an explanation of the much greater incidence of strains of these types in milk of cows at pasture until the source of such organisms is definitely established.

While the exact significance of the occurrence of certain types of coliform bacteria in milk is not definitely known, the fact has been firmly established that the presence of all such organisms in milk is, with rare exceptions, due to its contamination prior to removal from the byre, and the primary source of such contamination is in most instances bovine fæces. On farms where modern methods have not been adopted and little care is taken by the workers, the chances of the milk becoming contaminated with these bacteria are great, and as a rule they will be present in such milk, and frequently in large numbers. But where proper methods are adopted and care is taken, the milk will almost always contain few or no coliform bacteria. There may be occasional lapses from grace when coliform-positive samples will occur, but such samples will be exceptional. They will, however, serve a useful purpose by indicating that there has been a lowering of the standard of hygienic milk production, and that greater efforts must be made. It must always be borne in mind by the milk producer that, while it is essential to attain a high standard in the production of pure milk, it is even more important to maintain that standard both in summer and winter. The maintenance of a hygienic milk supply, with freedom from coliform contamination, depends essentially on clean, well-steamed utensils, clean cows, careful workers, efficient cooling, and protection from dust and flies.

THE MINERAL AND VITAMIN REQUIREMENT OF DAIRY CATTLE

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During the last fifteen years a great amount of work has been done on the rôle of vitamins and minerals in nutrition. The discovery that unknown substances in foodstuffs were essential for health and for growth and reproduction, and that the amounts and proportions of certain inorganic salts in the ration were of more importance than was at one time thought, led workers in all countries to concentrate on this new field of research, and literally thousands of experiments have been carried out to gain further

information on these aspects of feeding. In spite of the amount of work which has been done, our information is still incomplete. Certain facts, however, have become established, and much of the information of practical importance is now adopted in practice. Most reputable manufacturers of feeding stuffs have adjusted their rations, especially for pigs and poultry, so that they contain a sufficiency of both minerals and vitamins.

In most of the research work which was done to ascertain the rôle of minerals and vitamins, rations were used which were designed to be deficient in these, and the addition of the substances which were deficient gave striking results. As a result of the publication of these experiments many proprietary mixtures of much the same nature as those which have been used in experimental work were put on the market. In cases where deficient rations were being used these mixtures gave excellent results. In practice, however, rations are not usually so deficient as those used in experiments, and the object of more recent work has been to ascertain to what extent rations in ordinary use require the addition of minerals or vitamins, and how these deficiencies can be best and most economically made good. It is obvious that the feeding of supplementary minerals or vitamins is only a second-best method, and should be used only in special cases. The ideal ration is one which consists of foodstuffs which supply all the minerals and vitamins in their natural form.

In the case of the dairy cow, the problem is one of great importance on account of the drain of these substances in the milk yield. Milk is rich in all the substances required for health and growth. The modern cow giving up to two thousand gallons of milk per year suffers a very heavy drain on her constitution, and in addition this takes place under artificial conditions of housing and diet. The risk of depletion with subsequent loss of health in the cow is therefore correspondingly great. On the other hand, fortunately, many of the foodstuffs used in feeding dairy cows are rich in both minerals and vitamins. On good pasture, which contains everything, there is no need of any supplement with the possible exception of ordinary common salt, which can be supplied by giving the animal access to a lump of rock salt in the pastures. In winter feeding, however, where the maintenance ration may consist of turnips and straw, and the production ration of cereal grains which are deficient in some of the minerals and vitamins, it is necessary to take special account of the mineral and vitamin supply.

Of the many mineral elements contained in foodstuffs, it is necessary to consider only those most likely to be deficient in practice, viz., sodium, chlorine, iodine, calcium, and phosphorus. It is seldom that all these elements are deficient in the same ration. The extent of such a deficiency as may occur will depend on a number of factors, such as the rate of growth, the amount of milk

produced, the kind of crops fed, and the nature of the soil on which the crops are grown.

Sodium and Chlorine.—Common salt supplies sodium and chlorine, both of which are necessary for the well-being of cattle. and the dairy cow in particular. The daily salt requirement of cattle varies considerably according to the ration fed, the amount of milk produced, and the individuality of the animal. In practice it is considered advisable to add 1 lb. of salt to each cwt. of concentrates and in addition to allow all animals free access to salt licks. Where animals have been starved of salt, they should be given small daily quantities until the craving has disappeared. Such animals, if allowed free access to salt, may over-eat to such an extent as to cause severe digestive troubles.

Iodine.—While there is no clinical evidence that a deficiency of iodine occurs to any extent in this country, it is the opinion of some stockmen that beneficial results, especially as regards reproduction, have followed the administration of iodine to dairy cows. Iodine may be conveniently supplied by adding 2 oz. of finely ground potassium iodide to each 100 lb. of salt used to meet the salt requirement. Any communication from readers in regard to their experiences with the use of iodine in practice would be appreciated by the author of this article.

Calcium and Phosphorus.—The two mineral elements most likely to be deficient in the ration are calcium (lime) and phosphorus. These two minerals combined make up about 85 per cent. of the bone and about 90 per cent. of the minerals of the animal body. They constitute about 50 per cent. of the minerals in milk. An adequate supply is therefore necessary for healthy nutrition. Calcium and phosphorus are deposited in the bones in the rather constant ratio of about twice as much calcium as phosphorus, and this ratio of 2 : 1 is considered to be about the most desirable ratio of calcium to phosphorus to feed in the ration. Minor variations in this ratio, however, need not cause concern. In order to select rations that will meet the calcium and phosphorus requirements of farm animals, and also to know when a ration may be deficient in these elements, it is necessary to know something of the calcium and phosphorus contents of the foodstuffs used. The following table shows the calcium and phosphorus contents of some of the foodstuffs most commonly fed to dairy cattle in Scotland :—

Approximate Calcium and Phosphorus Contents of some Common Foodstuffs

	Percentages of Calcium (CaO).	Percentages of Phosphorus (P_2O_5).
Maize	·01	·63
Oats	·10	·70
Barley	·06	·79

	Percentages of Calcium (CaO).	Percentages of Phosphorus (P_2O_5)
Linseed Cake	·52	1·86
Bean Meal	·16	1·20
Earth-nut Flakes	·25	1·35
Soya-cake Meal	·36	1·30
Sharps or Middlings	·10	1·55
Distillers' Grains (wet)	·08	·26
Wheat Bran	·10	2·40
Fish Meal	10·20	8·40
Turnips (Swedes)	·05	·09
Cabbage	·30	·13
Thousand-headed Kale	·20	·15
Oat Straw	·30	·24
Good Hay	1·70	·42
Poor Hay	·86	·35
Good Pasture [1]	1·00	·73
Poor Pasture [1]	·35	·30

It will be seen from the above table that rations containing liberal quantities of good hay and pasture are not likely to be deficient in calcium, nor are rations containing liberal quantities of bran, bean meal, linseed meal, soya meal, and good pasture deficient in phosphorus. On good pastures, unless perhaps in the case of exceptionally high yielders, dairy cows are not likely to suffer from a deficiency of either calcium or phosphorus. But on the other hand, a winter ration of turnips, oat straw, distillers' grains or draff, and oats would be very deficient in calcium. Where rations cannot be compounded of both calcium and phosphorus rich foodstuffs, or where the stockman wishes to take precautions against a possible deficiency, the addition of 25 lb. of steamed bone flour to each ton of concentrates should obviate the risk of any lack of calcium or phosphorus except in very extreme cases. Steamed bone flour contains 24 per cent. of calcium and 15 per cent. of phosphorus.

Vitamins.—As far as our knowledge goes, the two vitamins which are most likely to be deficient in the winter rations of dairy cows are vitamin A, which is necessary for preserving health and vigour, and vitamin D, which aids in calcium fixation. Both these are present in green food, and well-cured hay is rich in vitamin D. Experiments have shown that a higher assimilation of calcium is obtained from well-cured hay than from hay which has been badly harvested or spoiled by rain. Sunshine has also a beneficial effect on calcium assimilation. The amounts of vitamins A and D in milk are said to vary with the supply in the food, and in view of their importance in human nutrition, it is desirable that the rations of dairy cows should be as rich in these substances as possible.

[1] In the case of pasture, percentages are expressed on dry-matter basis.

Complex Mineral Mixtures.—Since the importance of the mineral requirements of animals has been emphasised in the scientific journals, many proprietary mineral mixtures have appeared on the market, and misleading publicity has been given to the beneficial effects following their use. Some of these mixtures are honestly compounded, advertised, and priced, others, the composition of which may not be disclosed, are claimed to be the panacea of all feeding troubles, and are sold at exorbitant prices. The farmer should buy only from those firms willing to disclose and guarantee the composition of their product. In the light of present-day knowledge, there is no necessity to pay for any other minerals than salt, iodine, calcium, and phosphorus, and the economy of a proprietary mixture may be judged by comparing its price with that of common salt, steamed bone flour, and potassium iodide.

When and How to Feed Mineral Supplements.—The feeding of mineral supplements should not be regarded as a corrective for careless feeding practices. On the basis of present knowledge, it appears that the best way to feed minerals is by the use of foods rich in these substances, and that the feeding of mineral supplement is only a second-best method. The farmer should pay as close attention to the mineral content of the ration as to its content of other nutrients. It may be found, for example, that a deficiency of calcium can be corrected by feeding hay or a deficiency of phosphorus by the inclusion of bran in the ration. An adequate supply of mineral matter is as important during the dry period as during the height of lactation, because from the results of balance experiments, it appears that it is at the end of lactation and during the dry period that the dairy cow makes good any losses and lays up a reserve of mineral matter in preparation for the next lactation. The supply of vitamins A and D can be ensured by feeding green food whenever possible, or good hay, and allowing the animals to get as much sunshine as possible during the winter months.

The nutrition of dairy cattle, especially as regards their vitamin and mineral requirements, will become easier and safer when we can produce more green crops during winter, and extend the length of the grazing season. This is already being done by the cultivation of such forages as cabbage and kale during the winter, and by the selection and cultivation of grasses which will grow early or late in the season. The raising of the mineral content of these crops by manuring and selection is also of great importance. The drying of green foods, *e.g.* drying of young grass, may be a method of furnishing a winter food retaining all its natural nutritive value, including both minerals and vitamin content. This process is at present under investigation and will be the subject of a future article.

The Storage of New Potatoes

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A short article, discussing the possibilities of preserving over winter such qualities of new potatoes as appeal to certain consumers at the beginning of the year, was published in this Journal two years ago (2). It was pointed out that a limited but definite demand exists for the fresh flavour and appearance of a new potato long before the home crop is ready, and that this demand accounts for a ready sale, at enhanced prices, of imported produce. It was also shown, as a result of some preliminary experiments, that a small proportion of home-grown tubers might readily be specially stored at a reasonable cost to meet this demand. These experiments have been continued, and a brief statement of the results obtained during the last two years is given below.

Any consideration of preserving the appearance and quality of potatoes involves the question of avoiding loss in tuber weight, and therefore must take into account various factors, *e.g.* temperature and moisture, which control the biochemical changes of the tuber during storage. The importance of the conditions of storage has been adequately demonstrated by many investigators, particularly in Germany and the United States, who have given attention to such problems as preserving the main crop, maintaining the vitality of seed, or reducing the dormancy period. Special stores, in which humidity or temperature or an artificial atmosphere may be maintained constant, have been used with considerable success in this country for the preservation of fruit and meat, but, in this investigation, attention has so far been directed entirely towards finding a method for storing potatoes which would be cheap and practicable on almost any farm.

Growing the Potatoes.—Since one of the highly-valued characteristics of "new potatoes" is the thin skin, it is obviously important that the potatoes be lifted when still immature. As previously mentioned, this may be done either by anticipating the usual harvest by about a fortnight or by planting so late that maturity is not reached by the end of the summer. Two disadvantages of the latter method have been encountered. In 1930 the crops, which were planted as late as July, grew rapidly but were very severely attacked by blight; in 1933 growth was seriously affected by the drought. Practically all the observations, therefore, apply to crops which have been planted at the usual time but lifted early. The actual dates of lifting depended, of course, upon variety, locality, and season, but the crops were still growing and considerable sacrifices in yield were made. Even then it was common to err on the late side.

The necessity for handling immature tubers immediately in-

troduces a difficulty, for it is well known that they exhibit a greater respiratory activity than mature tubers, and tend to lose weight more rapidly immediately after harvest. The loss in weight during the early stages is relatively high and is due partly to the high rate of gaseous diffusion through the immature skin and injured surfaces of the tubers. Mechanical injury, which is bound to be greater amongst immature tubers, also increases the risk of loss through decay during storage. Fortunately, however, the loss in weight due to respiration is small compared to the loss due to evaporation of water, which may be controlled as shown below.

Variety.—Both early and second-early varieties have been employed in these experiments, chief consideration having been given to appearance, including shape, depth of eye, smoothness of skin, and colour of flesh; but the flavour and texture of "new potatoes" when cooked have also been borne in mind. No difficulty has been experienced in keeping the tubers in a firm, sound condition, but the skin in certain varieties (*e.g.* Epicure, Great Scot) generally darkens and becomes rough on storage, and an effective means of delaying the sprouting of early varieties has not yet been found.

The loss in tuber weight may be very small during the rest period which succeeds the period of intense respiratory activity immediately after harvest, but as soon as growth commences the loss in weight begins to increase rapidly. Two simple methods of inhibiting germination have been tried. As described below, mixtures of peat-moss litter and sand have been used for packing purposes, and it was found that the moist acid peat slowly decomposed calcium carbonate with evolution of carbon dioxide. High concentrations of carbon dioxide may reduce the dormancy period and hasten sprouting (5), but moderate concentrations of carbon dioxide have proved to be beneficial in the storage of both fruit and animal products (1). It was thought, therefore, that an atmosphere slightly enriched in this gas, by mixing calcium carbonate with the packing material, might reduce respiration and delay germination in potatoes; but the results obtained both in the laboratory and in the field have not been conclusive. The second method was an attempt to put to practical use the curious fact that the vapours emanating from ripe apples modify or, if sufficiently concentrated, inhibit the growth of a great many germinating seedlings and the sprouting of potato tubers (1). The influence on normal development, moreover, apparently does not affect to any extent the usual biochemical changes in the tissues. In a series of experiments, apples were packed along with the potatoes but effected no reduction in the degree of sprouting of the early variety Eclipse. The failure is by no means conclusive evidence against the applicability of the method, and further attention will be given to it when more definite information on the active constituent of the emanation is available.

A moderate amount of sprouting may actually have little or no effect upon the firmness and appearance or weight of the tuber—provided the storage conditions have been satisfactory—but it is certainly an undesirable feature and makes it necessary to confine attention in the meantime to varieties of later maturity. Of these, King Edward meets the requirements almost perfectly in all respects. Its kidney or oval shape, its smooth skin with pink patches, and its shallow eyes give it a most attractive outward appearance, and although its flesh is not quite white, it has a suitable quality on cooking. Other varieties which might be suitable are Evergood and Royal Kidney, but no experiments have been carried out with them. Cooking quality is, of course, undoubtedly a matter of personal taste, as numerous tests during the investigation have demonstrated, for while there has always seemed to be a consensus of opinion that a variety like Duke of York did not possess the taste associated with "new potatoes," considerable differences of opinion have been expressed regarding the comparative flavours of such varieties as Eclipse, Epicure, and King Edward, or Red Kings. The first essential is therefore the selection of a variety which has a suitable appearance, will not sprout too soon, and yet approaches the "new potato" in cooking quality.

Storage.—The important factors in storage are temperature, humidity, light, and ventilation. Weight losses obviously depend under any conditions upon variety and maturity and the quality of the material stored, but these were strictly under control. Generally speaking, low losses are associated with low temperature and high relative humidity and with slow circulation of air. All these conditions naturally lead to a low degree of evaporation, and therefore restrict transpiration from the tubers. Long storage at temperatures in the neighbourhood of freezing-point has a most injurious effect on potatoes, and temperatures of about 36° F. to 40° F. seem to be most suitable (4). It has also been observed that a short storage at temperatures of 63° F. to 68° F. speeds up the repair of mechanical injuries and materially reduces the losses due to evaporation of moisture and decay in subsequent storage (3). Other points which must be considered are that the bulking of potatoes causes a rise in temperature, and that the complete absence of ventilation may lead to a breakdown of the cells followed by bacterial rot and a more or less general collapse. Two failures under field conditions have been attributed to these causes; under laboratory conditions, only an occasional case of a tuber shrivelled through dry rot has been found.

These observations and the earlier work reported indicated that the greatest chance of success in this investigation lay in providing a storage in which the temperature was confined between fairly narrow limits, about 40° F., and the relative humidity was maintained near saturation. The use of a moist packing material served the manifold purpose of reducing abrasion of the immature tubers,

keeping them moist and restricting the possible spread of disease from any affected tubers. A moist skin increases the rate of respiration, but, as already mentioned, the change in weight due to loss of carbon dioxide is small compared to that due to transpiration of water.

Throughout the investigation, therefore, the tubers have been carefully packed in mixtures of approximately equal volumes of peat and sand containing different quantities of water. In the laboratory, wood and perforated tin boxes have been employed and stored at a temperature of about 40° F. On a semi-commercial scale, pits dug in sandy soils have been filled to within 6 to 12 inches of the surface and then covered up, but this has not been wholly successful. Packing the tubers in seed boxes and burying these in sand proved more effective; but the greatest measure of success has been attained by packing the tubers in ordinary fruit barrels of about 2 or 2½ cubic feet capacity, and storing these in a cellar in which the temperature fluctuated slightly in the neighbourhood of 40° F. These barrels each held about 40 to 50 lb. potatoes in six or seven layers, with a similar weight of packing interspersed, and seemed to permit of adequate aeration and yet prevent a serious fall in the moisture content of the packing material.

Results.—Figures are given in the accompanying table to illustrate the principal features of the results as affected by moisture of the packing material, the addition of 1 per cent. of calcium carbonate to the dry peat before mixing with sand and water, and the presence of an apple amongst the tubers. With regard to the moisture content of the packing material, it has generally been observed that, as the percentage of moisture was increased from about 5 (air dry condition) to about 15, the degree of sprouting in any variety increased, but the loss in the weight and moisture content of the tuber decreased. That is revealed in columns 1 and 2, 4 and 8, 5 and 7. It seems that a moisture content averaging between 10 and 12 per cent. during storage is most successful in keeping tuber weight and dry matter constant and at the same time keeping any sprouting that is liable to occur within reasonable limits. The loss in tuber weight found for dry packing (column 1) is of the same order as that which occurs between autumn and early spring in the normal storage of potatoes, but that loss is responsible for an absence of the firmness of freshly dug potatoes.

A comparison of the figures in columns 2 and 3 shows that the presence of calcium carbonate has effected a considerable reduction in sprout formation and loss of tuber weight, although the latter may have been assisted by the slightly greater moisture content of the packing. This effect, however, has not been general with other varieties, such as Duke of York, and the question would require further study.

As stated above, the use of apples in these experiments has not proved a successful means of inhibiting sprouting, and the figures

Results showing the Effect of Storage upon the Weight of Potato Tubers

No.	1	2	3	4	5	6	7	8
Date stored	10 8.32	10.8.32	10.8 32	26.8.32	8.9.33	8 9.33	7.9.33	7.9.33
Date opened	12.1.33	12.1.33	12 1.33	12 1.33	17.1.34	17.1.34	20.1.34	20.1.34
Conditions	wood box	tin box	tin box + 1% $CaCO_3$	tin box	tin box	tin box with apple	barrel	barrel
Variety	Epicure	Epicure	Epicure	K. Edward	Eclipse	Eclipse	Eclipse	K. Edward
% moisture in packing: original	5·1	11·6	12·9	16·4	13·4	13·4	13·6	13·1
% moisture in packing: final	4·3	8·9	10·5	14·6	10·9	10·9	9·3	9·6
weight of tubers: original	848	882	951	862	652	667	..	..
weight of tubers: final	787	832	964	866	650	663	..	..
weight of tubers: % change	−7·2	−5·7	+1·4	+0·5	−0·3	−0·6	..	..
% weight of sprouts	2·6	5·3	1·8	nil	0·7	1·3	sprouted	no sprouts
% moisture in tubers: original	79·1	79·1	79·1	76·2	80·2	80·2	80·2	78·2
% moisture in tubers: final	76·1	78·9	79·3	78·2	81·1	81·1	79·8	77·7

in columns 5 and 6 are typical of the results obtained. It is not known whether the apples employed were not at the correct stage of ripeness, which is important, or whether the packing absorbed or prevented the diffusion of the emanation. It is quite possible that a different technique might be devised to meet the case should it be desired to store early varieties.

It might be added that, although some form of moist packing material is a convenient method of maintaining a suitable humidity in absence of special storage facilities, it is not suggested that a mixture of peat-moss litter and sand is the only effective material.

Conclusion.—The granulated peat absorbs and helps to retain the moisture, while the sand aids the aeration and, incidentally, reduces the cost of packing ; potatoes, which are most attractive in appearance and meet with a ready sale, can be turned out of such a mixture. A change in the nature of the packing might require some adjustment in the moisture content recommended above. Fruit barrels, or something similar, are easily obtainable, and suitable storage accommodation could be arranged on most farms by the exercise of a little ingenuity. The method described, therefore, seems to be quite within the scope of the average grower who is prepared to give a reasonable amount of care and consideration to the handling of a small quantity of special material which will command a special price.

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Notes from Agricultural Colleges

Craibstone

Oats, 1933.—A snowstorm at the end of February and beginning of March delayed the start of sowing operations until the middle of March. After that, however, the weather was so good and the soil in such good condition that all sowing was done in record time before the end of the month. The crop brairded quickly and thickly, and looked well until the latter part of June, when some varieties showed signs of suffering. By this time the soil was very dry, as during April, May, and June there had been only about 3¾ inches

of rain. About 3½ inches of rain, however, fell in July, mostly during the second and fourth weeks, and although this had little effect in moistening the soil, it was generally sufficient to keep the plants growing. The varieties that suffered most from the dry conditions were Yielder, Elder, Early Miller, Pure Line, and R30, especially when sown on yaval. After lea there was more moisture in the soil, and the suffering was less.

The yields per acre, as will be seen from the results given later, were much higher than one would have expected after such dry conditions. The grain, however, was not so well filled, as will be seen from the following table which shows the relative weights of several varieties from the 1932 and 1933 crops. In all cases the grain was dressed and ready for sowing.

WEIGHT OF 1000 GRAINS

	1932 crop Grammes	1933 crop Grammes
Castleton	39·8	31·5
Pure Line	39·4	32·6
Sandy	30·4	25·6
The Bell	37·4	30·7
Victory	44·2	37·1
Star	46·1	41·6
Elder.	39·7	32·0
Yielder	50·1	44·8
Eagle	45·7	38·2

In previous trials on our soil the disadvantages of late sowing had been well demonstrated. The earlier sowings, however, had varied somewhat in different seasons, and last year with both Castleton Potato and Victory, that sown on 29th March was best, the yield from sowings both before and after that date being poorer.

EFFECT OF TIME OF SOWING—1933

	Per Acre			
	Potato		Victory	
	Grain cwt.	Straw cwt.	Grain cwt.	Straw cwt.
March 15th .	25·5	43·5	26·0	52·0
,, 22nd .	27·0	48·0	31·5	50·5
,, 29th .	30·2	52·2	35·2	47·7
April 5th .	27·7	50·7	34·0	47·0
,, 12th .	24·5	48·5	32·1	50·0
,, 19th .	20·7	45·5	20·7	49·7
,, 26th .	16·5	37·5	15·5	34·5

It is now generally recognised that a well graded sample of seed

is an advantage, and its value was brought out even better than usual by the extremely dry conditions. In the plot sown with the original ungraded sample, the larger number of plants present extracted more moisture from the soil without the plants being able to make full use of it, while the plants from the small grains appeared to suffer more than those from the large grains. Possibly the roots of the latter were able to go deeper. The same number of seeds was sown in B and C. The 1933 results were as follows :—

Rate of Seeding		Crop per Acre Grain cwt.	Straw cwt.
A. 300 lb.	Original sample . .	18·0	36·0
B. 224 ,,	Same sample with small sifted out . . .	21·5	48·5
C. 132 ,,	Small grains . . .	12·0	30·0

A trial was again made on a field after lea with wild white clover to ascertain if the standing power of several comparatively new varieties was better than any of the best of the older varieties. It was not a good season for such a trial, as none of the varieties was laid, and the only varieties that were slightly leaning were Castleton Potato, Victory, and Marvellous. The following are the yields obtained :—

OATS—1933

	Order of Ripening	Per acre Grain cwt	Straw cwt.
S.S.P.B. 656 . .	1	21·9	32·1
Yielder . . .	2	30·0	44·4
S.S.P.B. 644 (Early Miller)	3	30·2	42·6
New Potato . . .	4	24·6	43·2
Pure Line . . .	5	27·6	45·6
Marvellous . . .	6	29·7	44·1
Castleton Potato . .	7	26·7	44·7
R.30	8	25·8	34·8
S.S.P.B. 657 } . .	9	28·8	36·6
Eagle }		36·9	38·2
Victory . . .	10	35·1	47·1
Elder } . .	11	32·4	45·0
Stormont Arrow }		32·1	44·7

S.S.P.B. 656 and 657 are two new dwarf varieties from the Scottish Plant Breeding Station, but the first being so early and dwarf suffered more than most of the other varieties. It would require to be tried under much better conditions of both soil and climate. Although S.S.P.B. 644 (from the same source and now

named Early Miller) has been tried for three years, there has been no suitable opportunity of testing its value as a standing variety, but its appearance indicates that it should be good in this respect.

Three American varieties—Alaska, Minrus, and Anthony—were also included in this trial, but they were so early that the birds destroyed much of the grain.

Several trials with mercuric compounds were again carried out. In one trial half of the seed of seven varieties of oats was treated with Ceresan, the other half being untreated. Two plots were sown with treated and two with untreated seed, the same amount being sown in each case.

As in the previous trials, the braird on the treated plots was thicker and the plants were stronger than in the untreated. The following average result was obtained :—

OATS—1933

	Order of Ripening	Treated Grain cwt.	Treated Straw cwt.	Untreated Grain cwt.	Untreated Straw cwt.
Yielder . .	1	18·1	28·2	17·0	26·5
S.S.P.B. 644 .	2	21·1	29·9	18·4	28·4
Eagle . .	3	28·4	36·3	23·0	29·9
Star . .	4	26·6	34·5	18·7	27·6
McGS 97/10 .	5	26·3	31·0	22·3	27·4
Victory . .	6	24·1	30·6	21·2	27·7
Elder . .	7	20·6	29·5	18·4	26·6
Average . .		23·5	31·4	19·9	27·7
Average increase		3·6	3·7	..	..

Since Ceresan was first used many other mercuric preparations have been introduced. A trial was made with fully a dozen of these, Star being the variety of oat used, and four plots of each material were sown. The following average results were obtained from the materials that were best :—

	Average number of plants per square yard	Average yield per acre Grain cwt.	Average yield per acre Straw cwt.
Abavit, New .	363	27	41
Agrosan . .	356	27	40½
Leytosan . .	366	26¾	40¼
New Ceresan .	358	27	40¼
Untreated . .	285	25	38

These results indicate that these materials are of equal value.

In order to ascertain whether it is safe to treat seed oats some considerable time beforehand without damaging it, seed of Star was treated with several different materials in January, and again at the end of March just before sowing time. A portion of the seed at each time was treated with the recommended quantity (2 oz. per bushel) while another portion of the seed was treated with only half of this quantity (1 oz. per bushel). The following average results were obtained :—

	Average number of plants per square yard	Average yield per acre Grain cwt.	Straw cwt.
January—2 oz.	357	25·6	37·3
1 oz.	373	26·2	38·2
March —2 oz.	369	26·6	35·5
1 oz.	345	25·6	37·0
Untreated	285	24·5	34·2

Judging from the average number of plants in the plots, these results indicate that when the seed is treated beforehand a smaller amount of material may be quite sufficient, whereas when treated just before sowing the recommended quantity is necessary. This trial is being repeated.

One point to keep in mind is that the treatment must be thoroughly done so that every seed is coated with the material.

In another trial carried out in another field after a turnip crop, the treated seed did not at any time show any improvement over the untreated. There were no more plants per square yard, neither were they any more vigorous, as in the other trials.

In this case, the seed was sown at the end of March immediately after the field was ploughed. Comparatively dry weather followed, so that the surface soil was never wet but just sufficiently moist for the seed to braird quickly and vigorously. The soil temperature was also somewhat higher than usual for the time of year. In all probability these conditions did not favour the leaf-stripe fungus. In the other trials the fields were ploughed beforehand, and the soil was consequently more consolidated and moist and more likely to be favourable to the growth of the fungus.

The effect of different thicknesses of seeding (using treated seed) was again tried with several different varieties at the following rates—3, 2½, 2, and 1½ cwt. per acre. All were sown broadcast. The effect on the growing crop was very marked and attracted the attention of visitors who inspected the different crops. Generally, the crops from the thickest seeding were thick and comparatively short, whereas the crops from the thinnest seeding were distinctly thinner and taller and the plants were stronger with larger ears. In the case of the Castleton Potato Oat, the crop in the 3 cwt. plot was laid in places, whereas all the others were standing.

The yields obtained were as follows :—

OATS—1933

Effect of Thickness of Seeding

Seeding	1½ cwt. Grain	1½ cwt. Straw	2 cwt. Grain	2 cwt. Straw	2½ cwt. Grain	2½ cwt. Straw	3 cwt. Grain	3 cwt. Straw
Castleton . .	20·4	30·0	24·0	34·4	23·7	35·9	21·0	33·0
Elder . .	28·1	35·0	30·1	35·8	25·7	34·0	24·1	37·4
Pure Line . .	17·7	22·1	19·7	29·2	16·9	25·0	19·0	27·0
Star . .	27·6	33·6	32·1	29·7	29·4	31·9	28·0	29·7
Victory . .	30·0	33·8	33·4	38·8	31·0	35·3	29·2	33·6
Yielder . .	21·4	29·0	23·3	28·4	24·0	30·7	22·6	28·3
Average .	24·2	30·6	27·1	32·7	25·1	32·1	24·2	31·4

On the average, and in all cases except Yielder, the plot sown at the rate of 2 cwt. per acre produced the largest amount of grain.

Auchincruive

Cattle Feeding.—A cattle-feeding experiment was carried out in the early part of the winter of 1933-34, with two main objects in view :—

(1) To determine the effect on rate of progress and quality of beef from rations showing considerable variation in the amounts of protein supplied.

(2) To ascertain the return from ordinary farm produce such as swedes, oats, hay, and straw when utilised in the production of beef and marketed as such.

For the feeding trial 24 Blue Grey and Galloway bullocks were purchased early in October. Of these 18 were Blue Greys (Shorthorn Galloway Crosses), and 6 Galloways. They were divided into three groups with 8 animals in each, and the groups were made as uniform as possible as regards breed, live weight, quality, etc. The cattle were housed in pairs in the admirably equipped cattle-feeding boxes at Auchincruive. The feeding trial was continued for a period of 12 weeks, by which time all of the animals were ready for slaughter.

The rations fed to the three groups were, up to a point, identical, being as follows :—

Swedes . . .	60 lb. daily for the first four weeks.
	66 lb. ,, ,, second ,,
	72 lb. ,, ,, third ,,
Ryegrass and Clover Hay . . .	10 lb.
Oat Straw . .	6 lb.
Concentrates . .	5 lb. at commencement, but increased by ½ lb. each fortnight to 7½ lb. in the final two-week period and averaging 6¼ lb. over the full feeding period.

The concentrates consisted of a mixture of 2 parts crushed oats, and one part of the foodstuff to be tested. The three feeding stuffs under trial were decorticated ground nut, decorticated cotton seed, and palm kernel, and in order that the mixture with the oats might be more uniform these foodstuffs were ground and fed in the form of meal.

The composition of these foodstuffs as determined by the Chemical Department was as follows :—

	Ground-nut Meal Per cent.	Cotton-seed Meal Per cent.	Palm-kernel Meal Per cent.
Moisture . . .	8·23	8·55	12·52
Oil	8·84	7·39	1·19
Protein . . .	45·22	38·52	17·78
Fibre	6·09	7·49	9·36
Ash	6·59	6·35	3·95
Sol. Carbos. . . . (By difference)	25·03	31·70	55·20

The average live weight of the cattle at the start and finish of the feeding trial and the average daily increase from the animals in the different groups was as follows :—

	Average Live Weight Start			Finish			Average daily Live-weight Inc.
	cwt.	qr.	lb.	cwt.	qr.	lb.	lb.
Group 1.							
Dec. Gr.-nut Meal .	8	2	17½	10	0	24½	2·08
Group 2.							
Dec. Cotton-seed Meal	8	2	17½	10	0	23	2·06
Group 3.							
Palm-kernel Meal .	8	2	17½	10	0	26	2·10

It is apparent that despite the big variation in the protein content of the meals included in the rations there was no difference in rate of progress as measured by live-weight increase.

At the end of the 12 weeks' feeding period the cattle were sold to the Kinning Park Co-operative Society, Ltd. The carcasses were particularly satisfactory in every case, but it was the opinion of the buyer of the cattle and of the College representatives, who were given every facility for inspecting the carcasses from the different groups, that the decorticated ground-nut meal produced the best quality of meat.

It would appear from the trial that, on the basis of live-weight increase, decorticated ground-nut meal, decorticated cotton-seed meal, and palm-kernel meal are, for beef production, very similar in value, when fed along with a ration of swedes, hay, straw, and oats.

To ascertain the return from the home-grown foods consumed it is necessary to take into account the inbuying and the selling price

of the cattle and the amount of food consumed. The relative facts may be briefly summarised as follows :—

Average inbuying price per bullock—October 1933	£15 17 6
Transport charges and sale expenses	0 9 6
Total . . .	£16 7 0
Average selling price, January 1934 . . .	22 10 0
(On a carcass-weight basis this was equivalent to 8½d. per lb. sinking offal)	
Balance, being difference between inbuying and selling price, less sale expenses . .	£6 3 0
Average cost of purchased foodstuff consumed per animal	£0 11 0
Balance, representing the return from the home-grown foods consumed	£5 12 0

The value of the farmyard manure, which amounted to fully 1 ton per bullock per month, is more than sufficient to cover cost of attendance and of bedding supplied, and these items may accordingly be left out of the calculation.

The total quantity of home-grown foods consumed per bullock was as follows :—

Swedes, an average of 66 lb. daily for 12 weeks .	total	49½ cwt.
Hay, 10 lb. daily for 12 weeks	,,	7½ ,,
Straw, 6 lb. ,, 12 ,, ...	,,	4½ ,,
Oats, an average of 4⅙ lb. daily for 12 weeks .	,,	3⅛ ,,

Apportioning the £5, 12s. over the home-grown foods fed to the cattle gives the following return for these :—

Swedes,	49½ cwt.	20/– per ton	. . .	£2 9 6	
Hay,	7½ ,,	60/– ,,	. . .	1 4 6	
Straw,	4½ ,,	30/– ,,	. . .	0 6 9	
Oats,	3⅛ ,,	£10 ,,	. . .	1 11 3	
					£5 12 0

From the foregoing it will be readily apparent that the home-grown foods consumed by the cattle and utilised in the production of beef have left fairly remunerative prices.

Reviews

The Foundations of Agricultural Economics. J. A. Venn, Litt.D. Cambridge University Press, 2nd Edition, 1933; pp. xx, 600; price 25s. net.

Dr Venn's book was originally published in 1923, and in the Preface he stated that it represented "an attempt to bring within reasonable compass some account of the origin and incidence of

the numerous economic problems which affect the agricultural community." In the new edition the work has been considerably enlarged, and much of it has been rewritten. The ten years that have passed have seen great developments in the agricultural policy of the United Kingdom. Dr Venn has rendered a most valuable service to agricultural economists and to many other classes of the community by the care he has devoted to bringing his record up to date (the Preface is dated 7th June 1933), and thus presenting a conspectus of his subject in a form that is nowhere else available.

While agriculture, the most ancient and essential industry of mankind, has received ample notice in the works of classical economists such as Ricardo and Mill, "agricultural economics," as a separate branch of research and instruction, is comparatively new. Dr Venn is well qualified to act as its exponent. He holds the position of Gilbey Lecturer in the History and Economics of Agriculture in the University of Cambridge; he was Statistician to the Food Production Department, 1917-19, and afterwards at the Ministry of Agriculture; and formerly as Fellow and now as President of Queens' College, he has been closely concerned in the affairs of an ancient landowning corporation. At the present time he is President of the Agricultural Economics Society.

The Introduction, which is one of the new portions of the book, deals succinctly with the special features of the science of economics in relation to agriculture, or "the study of man in his relations to the land." Three chapters follow on land tenure, medieval and modern; these lead to a discussion of size of holdings; then follow tithes, rates and taxes, labour, marketing, co-operation, forestry, statistics and crop estimating and forecasting; while two chapters are devoted to the wheat supply of the British Isles, as a matter of first-rate economic and political importance.

These chapters form Part I of the book, to which its title is now appropriated. The account of British agriculture during and after the war (brought up to date) is now separated as Part II, since it is concerned with economic history rather than with the general conditions, natural, social, and legal, under which agriculture is carried on.

While Dr Venn naturally disclaims any intention of writing a history of British, or even of English, agriculture, the various chapters of Part I necessarily include narrative as well as discussion of principles and illustrations of their application. The author has thrown his net widely, drawing much of his material from the Dominions and from foreign countries. Scotland plays a relatively small part, no doubt in the first place because many of the general statements apply to that country as well as to England, and in the second because it is beyond the scope of the work to deal fully with the special aspects wherein Scottish agricultural conditions and practice differ from those of England.

Dr Venn enjoys the advantage of having occupied an official position and being now free to express his opinions on matters of policy and administration. This he does not hesitate to do. While he regards the plan embodied in the Wheat Act as "a social and economic triumph," he holds that on national grounds a continuance of the sugar-beet subsidy after 1934 could not be defended. As a "dispassionate historian," he expresses surprise at the calm attitude with which farmers have accepted the measures by which they have been relieved of rates and the special provisions regarding their payment of Income Tax. After giving a full and interesting history of the development of agricultural statistics, he goes on to criticise the official estimates of the yield of crops on the ground that they do not deviate sufficiently from the average (the reporters under-estimating good crops and over-estimating bad ones), and do not, in England at any rate, show the gradual rise that might be expected from the course of technical improvement. The reader will find many other passages that arouse reflection and perhaps dissent.

A few inaccuracies may be mentioned. It is not the case that Irish seasonal workers have ceased to come to Scotland (page 250). Nor did the Marketing Act, 1931, permit of the regulation of "the sale, within the particular area, of the product, wherever it had been raised" (page 313). The Opposition of the day strove in vain to secure this end, which has now been achieved in another way by the provisions of the Act of 1933 for the control of imports. On the same page Dr Venn puts the poll on a marketing scheme before its submission to Parliament for approval instead of after it.

These are, however, but small blemishes in so large a work, full as it is of facts that have been collected and marshalled with industry and judgment, and of arguments that are expressed in clear and vigorous language. Mention should also be made of the numerous maps, tables, diagrams, and pictorial illustrations with which the book is furnished, of its excellent index, and of the handsome style in which it has been produced by the Cambridge University Press.

Dr Venn ends his book on a note of hopefulness—"What the future may bring to [the British farmer] no man can say, but, assuredly, a controlled monetary system, a rigid policy of import restriction, the pursuit of arable husbandry upon an extensive basis, or, possibly, an abundant supply of cheap electricity will, in due course, either singly or in combination, rehabilitate him. Be that time far distant or be it near, the agriculture of these Islands will then resume prosperity—its position it has never lost—and unborn generations will look back on the present situation as affording one of those many trials from which, during countless centuries, the industry has emerged unscathed but remoulded. Let its present representatives take off their hats to the past and their coats to the future."

Practical Animal Husbandry. Wm. C. Miller, M.R.C.V.S., and E. D. S. Robertson, M.R.C.V.S. Oliver & Boyd, Edinburgh.

The title of this publication is no misnomer. It would be difficult to conceive a more practical form of handbook for those interested in the care of animals than this compilation by Messrs Miller and Robertson. The guidance it gives in the thousand and one problems of animal husbandry is couched in plain, direct language, and the letterpress is copiously illustrated with drawings and photographs, admirably designed to make still clearer the instructions given in the text. Veterinary students will find the book a mine of information and an excellent help in their study of the subject for examination purposes; veterinary surgeons in practice should have it at hand as a manual of reference; while farmers and stockmen could have no more comprehensive and serviceable guide-book in dealing with the many problems and emergencies that arise in the management of farm animals.

There is no preliminary padding of verbiage. We are plunged at once right into the matter. The first sentence in the book is—"Always speak to a horse before touching it," and in a similar forthright manner the authors proceed to treat the handling of horses, cattle, sheep, pigs, dogs, and cats; the vices to which these animals are occasionally susceptible; and the administration of medicine to them.

The points of the horse and the conformation of both riding and work horses are fully detailed. Then comes a section dealing with the chief breeds of farm animals in Britain—a section which might perhaps have been omitted, or, if included, better placed.

Instructions are given in stable management and in the feeding and watering of horses; also in grooming, bedding, and clipping them. Similar notes are supplied for cattle and dogs, and the dipping of sheep is carefully dealt with. It is, however, a matter for consideration by the authors for any future edition of their book whether a better arrangement would not be to separate out the references to cattle, pigs, dogs, and cats, and to gather these into special sections for greater readiness of reference.

The chapters on the management of brood mares and of young horses are worth the careful attention of horse-breeders and trainers, and there are sections on hunting terms, the summering of hunters, the wintering of polo ponies, and other matters which should be of special interest to the sporting equestrian. The subjects of harness and saddlery, shoemaking, and dentition are very fully treated. Herd management in relation to cattle, cows, and bulls; the flock management of sheep; pig-breeding and rearing; and goat-keeping are all more or less fully discussed; but the section on poultry, while it has its good points, is much too condensed and scrappy to be quite satisfactory. One is inclined to think that the authors might have done better to confine this section to the disease side of

poultry. There is a plethora of general manuals of poultry-keeping on the market.

A list of works consulted is appended, and this should be useful to students and practitioners who want to read up the literature of the subject.

The format of the book and the quality of the illustrations do credit to the publishers.

Veterinary Hygiene. R. G. Linton, Ph.D., M.R.C.V.S. W. Green & Son, Ltd., Edinburgh.

The fact that a second edition of Professor Linton's textbook of *Veterinary Hygiene* has been called for is evidence of appreciation of its usefulness and authority. Opportunity has been taken to bring the subject matter up to date by revision and extension. The section on preventable diseases has been restricted to those notifiable in Great Britain, and that treating of sanitary law has been withdrawn, on the ground that the best source of information on points of law is the Act or Order concerned.

In regard to certain branches of his subject Professor Linton has wisely sought the assistance of those possessing specialised knowledge. For example, Miss H. Newbigin contributes a section on poultry housing, and Mr J. E. Wilson describes the more common poultry diseases and their treatment. Help has also been obtained from specialists on sewage treatment, sheep dips and disinfectants, the bacteriological examination of water, bovine abortion and bovine mastitis, tuberculosis, the housing of dogs, and one or two other matters.

It is obviously difficult to define the subject of Veterinary Hygiene exactly, and to determine what should and what should not be included in a handbook intended for students. Professor Linton casts his net widely and his conception of his subject seems to err on the side of comprehensiveness. Was there really any need to include a short treatise on Meteorology ? It is a little difficult to see the immediate relationship of technical descriptions of meteorological instruments, or of definitions of cirrus or cumulus clouds, and so forth, to the care and treatment of domestic animals. If Meteorology why not Geology or Botany ? One feels that the utility of the book to the veterinary student would be considerably increased if the limits of the subject were more narrowly drawn and if knowledge on more general matters were left to be gained from other sources.

The sections of the book dealing with sanitation, ventilation, building construction, and the control of disease are full and well authenticated, and the author has provided a store of information on both the scientific and the technical sides of these subjects.

The text is well supplemented by excellent illustrations and the get-up of the volume is first-rate.

The Young Man in Farming. A. K. Getman and P. W. Chapman. Chapman & Hall, Ltd., London.

There is in many American educational treatises an emotional strain which sounds rather simple and ingenuous, especially when it is combined, as in this publication, with an open and frank appeal to self-interest and the money-making instinct. The book is addressed to young Americans enrolled in junior high schools and in the early years of a curriculum in agriculture, who are looking forward to farming as a career. It starts from the premises that the American farmer of to-day can produce three times as much as his grandfather did: production of milk, for example, has doubled in the last fifty years though the number of cows is the same; that thus farming has changed from a mere self-supporting occupation to a complex commercialised process of production; and that therefore the modern farmer must have a wider outlook and a fuller training than his predecessor. His outlook, say the authors, must range over production of live stock and crops, farm management and accountancy, marketing, co-operation, maintenance of the home life, citizenship, and the wise use of leisure.

This leads to a plea for agricultural education and to an account of the rise and progress of American agricultural colleges and research institutions. The main reason for the young farmer's attendance at a college is put forward in a characteristic American way by quoting from a report by the Dean of Boston University College of Business Administration, which asserts that a man with little or no education might expect to earn in his lifetime, *i.e.* from 14 to 60 years of age, 45,000 dollars; a man with a high-school education might expect to earn 78,000 dollars; and a college-trained man 150,000 dollars.

" But," say the authors, " education has no money value except in relation to some vocation or avocation," and a whole chapter full of statistical data is devoted to proving the money value of this vocational training. It is fair to add that the chapter ends with a poem whose theme is close attention to business:

> " The chap who works the hardest
> Is the one who gets the most."

The proper course for an American youth who wants to succeed as a farmer is evidently, then, to go to a high school. But he should also at the same time become a member of the " Future Farmers of America ": first, as a " Green Hand "; second, passing on to a " Future Farmer "; then becoming a " State Farmer "; and finally blossoming out as an " American Farmer." But note that he cannot get this final " degree " until, in addition to a long list of other accomplishments, he has earned and invested 500 dollars.

The authors pass on to an elementary exposition of economic

principles—demand and supply; costs and profits; marketing methods; the balancing of production and consumption; tariffs and imports; price cycles; money and credit; relation of gold to prices. Then comes a chapter on thrift, investing, insuring, etc., and on the American banking system.

In treating of co-operation the writers give details of the institution and aims of the farmers' associations, known as: (1) the National Grange; (2) the Farmers' Union; and (3) the American Farm Bureau Federation. Among the aims of these institutions one is glad to note these:

"To hasten the good time coming."

"To garner the tears of the distressed, the blood of the martyrs, the laughter of innocent childhood, the sweat of honest labour, and the virtue of a happy home, as the brightest jewels known."

The characteristics of successful farmers are discovered by analysing in true American fashion the careers of the "Master Farmers"—the farmers selected as the best in each congressional district of thirty States. The analysis is made by means of a Score Card whose major divisions are:—

	Points
Operation and Organisation of the Farm	375
Business Methods and Ability	200
Appearance and Upkeep of Farm and Home	75
Home Life	250
Citizenship	100
Total	1000

Apparently, however, not even in the States is there unanimity on what are the desirable characteristics in the make-up of the successful farmer, for we are given an alternative Score Card drawn up by the "Master Farmers" themselves, and they ought surely to be good judges. They allot points as follows:—

	Points
Managerial Abilities	260
Mental and Educational Abilities	177
Financial Abilities	100
Live Stock and Crop Abilities	40
Physical Abilities	42
Miscellaneous Abilities	28
Personal Traits	218
Total	865

One regrets to observe that "Ability to rear a good family" is relegated to the Miscellaneous Group, and that the value attached to it in the Scoring is a paltry one point!

Needless to say that both the capital and the income of a Master Farmer are readily shown to be far beyond the average, as are also his yield per acre and his labour return.

The final chapter of the book deals with the future of American farming. The authors plead for a national policy for agriculture. They advocate the utmost development of the best lands; the retiring of marginal lands from cultivation and the State afforestation of these; and an endeavour to stabilise prices of agricultural produce.

Control of Bracken in Scotland

THE spread of bracken in Scotland during the past thirty or forty years has resulted in material losses to agriculture in many districts, particularly in the case of hill land, where the invasion of the weed has caused a serious reduction in grazing value and sheep-carrying capacity. It is recognised that an effective means of destroying or controlling the plant is an urgent need, and numerous experiments with that object in view have been carried out in recent years by various investigators. Unfortunately, their efforts to devise an effective and economical method of absolute eradication have not so far been successful. Some interesting and suggestive information has, however, been collected by workers on different aspects of the problem, and the following brief summary of the results achieved may be of interest.

Cutting.—It has been definitely established that persistent and systematic cutting over a period of from three to five years can effectively control bracken. Observations show that the best date for cutting may vary from the middle of June to the beginning of July (when the frond is almost fully expanded), followed, if necessary, by a second cutting six weeks later; and it is emphasised that it is essential to continue the cuttings at the proper season each year without interruption. Some investigators advocate that cutting should be supplemented by manuring, sowing of suitable grass mixtures, and, if possible, by heavy mixed stocking. It is stated that horses and cattle prevent spread, and that pig-grazing may be looked upon as a cure.

Little detailed information is available as to the comparative values of machine and hand cutting. The use of horse-drawn cutters is possible only in a limited number of cases, while the machine is apt to suffer from undue wear and tear, and generally hand cutting with scythes, hooks, or wire switches has proved to be the most effective method. Running chain harrows over ground where growth is young and tender has also been found useful. It is recognised that the use of an improved type of machine, capable of replacing hand labour in cutting bracken, would greatly reduce the cost and labour of treating extensive areas, and assistance has recently been provided from State funds to enable this possibility to be investigated. The two main obstacles to bracken cutting are firstly, the cost, and secondly, the difficulty of releasing the ordinary farm staffs for this work at a busy period of the year.

In a carefully planned experiment carried out in the years 1923-25 on about 500 acres of bracken on different types of land, the work of cutting was let by contract, and at the level of agricultural wages then ruling, the cost of clearing varied—according to the number of cuttings required and the nature of the area—from 10s. to 30s. per acre. The importance of employing whole-time extra labour rather than the ordinary farm staffs at intervals for this type of work is stressed by this investigator.

While the destruction of bracken may in a few cases not be financially or economically possible, the conclusion is that in most cases it could be done, and that the value of the land after clearing would be considerably greater than the cost of cutting.

Spraying.—A considerable amount of work on herbicides suitable for bracken destruction has been carried out by different workers, and promising results have been obtained. Common salt, sulphuric acid, copper sulphate, potassium chlorate, sodium carbonate, and sodium chlorate have all been applied, either in dry form or in solutions of varying strengths. Of these, sodium chlorate has given the best results. In one experiment the bracken was withered and dead a few days after a 1 per cent. solution (8 lb. sodium chlorate in 80 gallons of water per acre) had been applied. Another investigator, after three years' experiments, recommends dressing for two or three successive years with sodium chlorate in dry powder form at the rate of not less than 1 cwt. per acre. In his experience dry powder gave better results than the solution.

In spraying with sodium chlorate, as in cutting, the main limiting factor is again the cost, while there is danger of fire in using the powder, and the use of the solution is practicable only where there is an adequate supply of water readily available.

It is appreciated that unless spraying operations are likely to achieve ultimate absolute eradication, the bracken will be as robust as ever within a few years. Investigators are not yet in a position to claim that any of the herbicides tested will destroy bracken completely, but the results so far achieved are promising, and experiments will be continued.

The treatment of large tracts of bracken presents obvious difficulties, and the possibility of spraying from the air with a suitable herbicide is at present under consideration.

Control by Disease.—An epidemic of bracken disease in 1928 gave promise that it might be used for the control of bracken. A systematic investigation was made, but efforts to spread the disease artificially unfortunately proved unsuccessful. The botanical nature of the plant is now being investigated, with a view to discovering weak spots in its structure which might render it susceptible to disease.

As these notes indicate, the discovery of an economical and effective treatment for the complete eradication of bracken presents a difficult problem, and further investigation is necessary for its

solution. Meantime it is important that farmers and landowners should realise the necessity of checking the spread of the weed by using control methods which have proved effective. Useful advice on the subject is provided in Advisory Leaflet, No. 90, issued by the Ministry of Agriculture and Fisheries, copies of which may be obtained from H.M. Stationery Office, price 1d. per copy, or 9d. per dozen copies.

The Agricultural Marketing Act, 1933

In the issue of the Journal for October 1931 an account was given of the provisions of the Agricultural Marketing Act of that year. The principal criticism of that Act rested on the ground that it contained no provision for regulating the importation of agricultural products. One of the main objects of the new Act, which became law on 18th July 1933, is to enable the Board of Trade to regulate such importation (Part I); another is to provide for the framing of "development" schemes relating to secondary products derived from agricultural products (Part II); the Act of 1931 is considerably amended in various ways (Part III); and legislation enacted by the Parliament of Northern Ireland for the control of marketing enables that part of the United Kingdom to be included in the general provisions of the new Act.

In Part I of this Act, Section 1 empowers the Board of Trade, after consulting the three Ministers concerned with agriculture, to make an Order regulating the importation of any agricultural product in respect of which a marketing scheme exists or is in preparation, if the Board are satisfied that without such an Order the marketing organisation cannot be successful. The Board have to take into consideration the interests of consumers of the product to which the proposed Order relates, and have also to take account of existing treaties, conventions, and agreements with the Dominions and with foreign countries.

Section 2 confers an important power upon the Ministers concerned with agriculture. Where an Order is in force under Section 1, or where voluntary arrangements have been made for controlling the importation of an agricultural product, these Ministers may, if they think that such action is required "to secure the economic stability of any branch" of agriculture, control by Order the sale of the product in question, or a related product, by the producers or by marketing boards. Before taking such action the Ministers have to consult the Board of Trade and the Market Supply Committee, and the marketing boards concerned, if such exist.

The object of this provision is to enable the regulation of home supplies and the regulation of imports to be adjusted to each other in the interests of market stability.

Any Order made under Section 1 or Section 2 has to be laid before

Parliament, and is subject to an affirmative resolution of each House.

The Market Supply Committee, which has already been mentioned, is set up under Section 3. It is to be appointed by the Ministers concerned with agriculture for the purpose of reviewing generally "the circumstances affecting the supply of agricultural products in the United Kingdom," and making recommendations to these Ministers as to the steps, if any, that should in the opinion of the Committee be taken for regulating that supply, and is to consist of a Chairman and not more than four other persons.[1]

Part II of the Act deals with development schemes for organising the production of secondary agricultural products, which may be promoted by two or more marketing boards, one at least of which is concerned with a secondary product and one at least with the agricultural product from which it is derived. Bacon is specified in Section 7 as a secondary product, to which this part of the Act applies. Any other may be added by Order, duly affirmed by both Houses of Parliament.

A development scheme may be brought into existence by an Order made by the appropriate Minister and approved by Parliament. As it is promoted by marketing boards, there is no place in the procedure for a poll. By a subsequent section (18) the operation of a Reorganisation Commission is extended to cover the preparation of a development scheme, and such schemes are brought under the purview of Committees of Investigation.

The board set up under a development scheme is to be mainly concerned with the organisation and control of the production of, for example, bacon, by licensing producers, by buying up and disposing of inefficient or redundant factories, etc., and it is to obtain the necessary funds by levying contributions from the constituent marketing boards.

In Part III of the Act, Section 10 confers upon marketing boards the power of determining the quantity of the regulated product, or any description of it, that may be sold by a registered producer. This determination may be carried out "by reference to the quantity of that product . . . which was in some past period produced, sold, or otherwise dealt with on particular land or premises or by particular persons," or in other ways. This is an important addition to the powers of control conferred upon marketing boards by the earlier Act.

Section 11 enables the appropriate Minister to modify a marketing scheme by Order for the purpose of giving effect to an Order made under Part I of the Act. Section 12 makes more definite the power of a board to carry out the pooling and distribution of the proceeds of sales of the regulated product. Section 13 enables a board to negotiate with any other person (*e.g.* with retailers)

[1] Those actually appointed are the Marquess of Linlithgow (Chairman), Sir David Milne-Watson, Professor W. G. S. Adams, and Mr Frank Hodges.

about the marketing of the regulated product, and to bring into consultation in this matter some person either agreed upon by the parties or nominated by the Minister. The person (or persons) thus brought in cannot compel agreement, but the usefulness of such consultation has already been shown in the working of the English Milk Scheme. This voluntary consultation did not need legislative sanction but for the fact that boards had to be empowered to pay the person (or persons) concerned for their services.

Under Section 14 two persons "specially qualified by reason of commercial or financial ability" must be co-opted to a marketing board, after consultation with the Market Supply Committee, in addition to the elected members. This arrangement comes into force on the expiration of the term of office of the board as originally constituted, which includes two members nominated by the Minister. This section also allows the elected members to be elected either directly by the producers or by a body or bodies elected by the producers for that purpose.

Section 15 requires a marketing board to appoint an executive committee of not more than seven persons, including at least one of the co-opted members, to which all the board's functions are to be delegated except such as may be specifically reserved for the full board. Section 16 deals with compensation payable under schemes, and Section 17 with the effect of schemes on contracts; Section 18 has already been mentioned.

Part IV includes a number of miscellaneous provisions, mainly of a formal nature. Some are, however, of material importance, such as the provisions that contracts for the sale of hen and duck eggs shall be void unless the eggs are contracted to be sold by weight or under a grade designation (except in the case of sales of less than 25 eggs, or in that of imports or exports)—Section 20; that the Board of Trade shall have power to require returns to be made of stocks of agricultural products in store—Section 21; that marketing and development boards shall pay the cost incurred by Reorganisation Commissions in preparing schemes—Section 22; and that where a scheme fails to obtain Parliamentary approval the cost incurred by the promoters shall be paid out of the appropriate Marketing Fund.

Copies of the Act may be obtained from H.M. Stationery Office, 120 George Street, Edinburgh (and from the London, Manchester. Cardiff, and Belfast offices), price 9d., or by post, 10d.

A short Act, known as the Agricultural Marketing (No 2) Act, 1933, became law on 21st December of that year. While it is expressed in general terms, its main purpose is to enable the Pigs and Bacon Marketing Boards to make certain arrangements to meet losses expected to be incurred by bacon-curers in dealing with the pigs contracted for in the first contract period.

Agricultural Conditions

THE weather during December was exceptionally mild and dry for the time of the year. Cultivation made excellent progress, but in many cases the ground was almost too dry for the ploughing of grassland. In some of the eastern counties water again became scarce and extra labour was required to cart supplies for the use of farm animals, while in North and East Perth field drains had not yet begun to run at the end of the month. On farms where the machines are driven by water power the threshing of grain was delayed by the dry conditions, but farm work otherwise was far advanced and extra work, such as the repairing of roads, was undertaken. Extremely mild weather with rather high winds was general throughout January. In the west and south-west moderately heavy falls of rain occurred intermittently during the first half of the month, but farm work proceeded with comparatively little interruption. The mild and dry conditions continued during the first three weeks of February. The preparation of land for spring sowing was carried out without interruption and in early districts a start was made with the sowing of oats, while in Stirling some beans had been sown by the end of the month. In Kincardine and Dunbarton the planting of potatoes had begun and in Wigton the seeding of early potatoes, which had commenced before the end of January, was completed. Reports from North and East Perth, Kirkcudbright, and Wigton stated that shortage of water supplies in these districts was causing much concern to farmers. During the last week of February cold and stormy winds, with frost and snow, were general.

In most districts the work of sowing wheat had been completed before the end of the year. Where sown early the crop then had an extremely fresh and strong appearance. The mild and rather bright weather conditions throughout January, and the almost entire absence of frost and snow, had a remarkably beneficial effect on autumn-sown wheat, which at the beginning of February showed a strong, regular braird of good colour and fresh, promising appearance. In many parts of the country this season farmers have sown wheat on small areas of land where it has seldom, if ever, been grown before, and at the end of January indications were that in most of the principal wheat-growing districts the area under the crop will show an increase amounting to from 5 to 25 per cent., while in a few other districts the increase may amount to about 30 per cent. During the first three weeks of February the plants made excellent progress; growth was checked to some extent by the rather severe conditions during the last few days of the month, but, taken on the whole, the prospects for the crop were very promising at the beginning of March. A good proportion of the land intended for spring sowing was broken up during February, and in

several districts the work of seeding had made good progress under excellent weather and soil conditions.

The reports on the condition of last season's potato crop stated that the tubers were generally sound, clean, and healthy when taken from the pits. In the principal potato-growing areas in eastern districts, however, some varieties were badly affected with disease. On some farms in the Lothians, King Edward were badly diseased, while in several other eastern districts the condition of Kerr's Pink was extremely unsatisfactory, a very large proportion of the tubers having to be rejected when the crop was dressed. On many farms in Kincardine and South-West Angus half the crop was discarded. The mild weather in southern and south-western districts caused more sprouting than usual in the pits. In some western areas very few pits had been opened before the end of January.

The mild and open weather conditions during the winter were most favourable for sheep stocks; grazings remained fresh and green and the supplies of roots necessary for the feeding of ewe stocks were conserved. Flocks suffered a little from the stormy weather during January, but comparatively few losses were reported and their condition generally was very good. Except in districts where pastures suffered from lack of moisture, ewes were in fresh condition at the end of February and prospects for lambing were good. In Berwick and Lower Moray lambing had commenced before the end of January, and by the beginning of March a good start had been made among early flocks on low ground, particularly in eastern and north-eastern counties. The reports on the crop of lambs were generally fairly satisfactory, but in North-East Aberdeen it was stated that "single" lambs were more common than usual. With the favourable weather throughout the greater part of February lambs throve well and losses were less numerous than in previous years. The only complaint of disease among sheep flocks came from Harris and Uist, where scab was reported to be unusually troublesome.

That part of the root crops left in the fields continued to grow during December and showed a satisfactory increase in bulk. Conditions were favourable for the storing of roots, but owing to the uncertain condition of some of the turnips and the possibility that they would soon become decayed in the pits, fewer farmers than usual had stored their yellow turnips. Swedes generally proved to be a sound and healthy crop, and improved considerably in weight during the last few weeks of growth. As the general condition of pastures was above the normal for the season of the year, farmers drew less heavily than usual upon their stocks of turnips and fodder and fears of a shortage of keep were allayed. At the end of February fodder was fairly plentiful generally, although there was a scarcity of straw in a few areas. Supplies of turnips lasted better than was anticipated, but in some districts supplies were short and had been replaced by sugar-beet pulp or potatoes.

As agricultural work was exceptionally well advanced at the time of the Martinmas hirings, many farmers dispensed with the services of one or two workers for the winter months and in most districts a number of competent men were surplus to requirements. The extent of unemployment among regular farm workers was difficult to assess, but it was generally estimated at 1st January that of male workers perhaps 5 per cent. in the eastern counties failed to find employment for the winter, from 5 to 7½ per cent. in Roxburgh and Selkirk, from 12 to 15 per cent. in North-East Banff, about 15 per cent. in North-East Angus, and from 15 to 20 per cent. in Central Aberdeen. In western and south-western districts, however, there appeared to be very little unemployment among regular farm workers. Reports received at the end of February stated that in all districts the supply of workers, both regular and casual, was ample for all requirements, and in many areas was still in excess of the demand.

SCIENCE AND PRACTICE

The following extracts and summaries are supplied by members of the staffs of Scottish agricultural colleges and scientific institutions or are taken from recent bulletins of the International Institute of Agriculture. Full references to the original publications may be obtained on application to the Secretary, Department of Agriculture, York Buildings, Edinburgh.

CROPS AND SEEDS

The Bruce Club-root Resistant Turnip. Experiments on Farmers' Trials in Otago, Southland. *R. B. Tennant, Field Superintendent, Department of Agriculture, Dunedin. New Zealand Journal of Agriculture, Volume* 47, *No.* 5, 20*th November* 1933.—The experiences which have resulted from extensive trials in Otago and Southland with this variety are recorded and the characteristics of the turnip when grown under New Zealand conditions are described. It was obvious that the colour of the root is not yet a fixed characteristic. A fair proportion of green-top turnips with a rich orange coloration under the ground were noted in the lines of Bruce seed which were imported. This green-top variety, which is regarded as being distinct from Bruce, is a splendid type of turnip, and has now been segregated under the name of "Wallace"; it is also highly resistant to club-root. When grown under good conditions The Bruce turnip yielded highly, and on account of the close texture of its flesh it proved to be an excellent keeper.

All the farmers who grew The Bruce turnip last season did not obtain satisfactory results. It was obvious that some of the seed sold as Bruce was not of a disease-resistant strain. Where resistance to club-root was most marked, it was noted that the seed of such cases originated from one source.

The Effect of Potash on Starch in Potatoes. *G. V. C. Houghland and J. E. Schricker. Journal of the American Society of Agronomy, Volume* 25, *No.* 5, *May* 1933.—The following extracts are taken from the writers' summary :—"Three year averages of the results of these analyses did not show significant increases in the percentage of starch induced by applications of complete fertilisers containing as much as 10 per cent. potash. Furthermore, when the average analyses of potatoes from potash-treated and from no-potash plots for both early and late crops were compared, no significant increases in the percentage of starch were found in potatoes grown on the potash-treated plots. On the contrary, in a majority of cases potash additions to the fertiliser caused a slight depression in the starch percentage, and in this regard muriate of potash seemed to have a greater effect than sulphate.

"Likewise the potash additions depressed the percentage of dry matter in the potatoes, thus bringing about an increase in the starch-moisture ratio in nearly every case corresponding to the amount of potash addition. This ratio was higher when muriate of potash was substituted for sulphate.

"From the results of more than 300 starch analyses of potatoes grown on soil in one

case treated with fertiliser lacking potash and in the other subjected to potash treatment varying in amount and source, it appears that the possibility of regulating to any great extent the percentage of starch in potato tubers through altering the amount of available potash is but slight."

SOILS

The Destruction of Leather-Jackets by Chemical Methods. *Kaysing. Die Ernahrung der Pflanze*, 1934, *30*, 26-29.—On soils infested with leather-jackets, tests with naphthalene and kainit showed that in boxes the former was the more effective, but in the field its volatility made it less so than the latter. Experiments on rye oats, wheat, and barley showed that dressings of 9½ cwt. per acre kainit brought about complete destruction of the larvæ. When applied before seeding a much smaller dressing was effective, but further work is necessary to determine the most favourable time of application and the amount of kainit required.

The Economic Importance of Plant Protection by the use of Potash Manures. *Eisele. Die Ernahrung der Pflanze*, 1934, *30*, 66-68.—The protective action of potash against frost action is discussed and results of investigations on wheat, potatoes, and grape vines are given. The application of potash, which gives protection against drought and rust, prevents to some extent the lodging of grain crops, and promotes the growth of good quality grasses in pasture. Kainit also acts as a weed-killer, and can be used to eradicate slugs and wire-worms.

Observations on Water Content and Water Uptake of Oats showing Potash Starvation. *Schmalfuss. Zeit. Pf. Dung. u. Bodenkunde, A.*, 1934, *33*, 1/2, 28.—An account is given of a series of pot experiments on oats with and without the addition of potash, but in the presence of sufficient amounts of other plant nutrients. In the " no potash " series the yield obtained was about 65 per cent. of that obtained when potash was added; the " no potash " series was also later in ripening. Per unit weight of dry substance, it was found that 25 per cent. more water was used in the " no potash " series, *i.e.* where there was a potash deficiency transpiration was considerably greater.

The Use of Small Amounts of Nitrogen for Corn in addition to Phosphorus and Potassium. *Miles. Journ. Amer. Soc. Agron.*, 1934, *26*, 2, 129.—An account is given of experiments in Indiana for the comparison of phosphate-potash fertilisers with complete fertilisers when relatively small amounts of nitrogen are used. The effects of the various fertilisers on rate of growth and yield are discussed.

The Potassium-Lime Problem in Soils. *Jenny and Shade. Journ. Amer. Soc. Agron.*, 1934, *26*, 2, 162.—A description is given of laboratory investigations on the effect of calcium carbonate in liberating potassium from soil colloids, permutites and natural and artificial soils. In all the systems investigated, lime liberated absorbed potassium in large quantities. The effects of various anions and of hydrogen and possible effects of micro-organisms on this exchange reaction are discussed.

Available Phosphorus in Soil and the Phosphorus Content of Grain as influenced by Phosphorus Application to Soil. *Weidemann. Journ. Amer. Soc. Agron.*, 1934, *26*, 2, 170.—Experiments have been conducted with oats, rye, and wheat on a sandy loam. Data are presented showing the power of the soil to fix phosphoric acid, and showing the effects of various applications of phosphoric acid on the yield and phosphoric acid content of the plants.

DAIRYING

Effect of Pasteurisation on the Bacterial Flora of Low-count Milk. *Prouty* (1934). *Journ. Dairy Science*, *17* (2), 115.—When market milk of average quality is pasteurised under commercial conditions, it usually becomes sour if kept for more than 24 hours at ordinary temperatures. But when a high-grade milk is pasteurised under carefully controlled conditions, and is subsequently protected from contamination, it may not sour even after 3 or 4 days' storage; on the other hand, it frequently develops a disagreeable smell and taste. This, as the author and his colleagues at the Washington Agricultural Experiment Station show, is due to the fact that while the acid-producing organisms present in the primary milk have been mostly destroyed, proteolytic (casein digesting) and alkali-forming bacteria are left behind and bring about the undesirable changes in the odour and flavour of the milk. The author finds that if high-grade milk, pasteurised under commercial conditions, is consumed within 24 hours, such abnormal fermentations are not noticeably present, but when the heat-treated milk is kept for 36 to 48 hours at room temperature pronounced abnormalities other than souring are usually in evidence.

The author suggests that in order to overcome this condition pure cultures of lactic acid-producing organisms might be added to the milk after pasteurisation and before bottling.

ANIMAL BREEDING

Cattle

Pedigree as a Basis for selecting Dairy Bull Calves. *Lynn Copeland.* 1934. *Journ. Dairy Science, 17*, 93-101.—"Proved sires have been advocated greatly during recent years as the soundest means of herd improvement. In view of the evidence advanced by critical research and the results of practical dairy experience, there seems to be little argument about this point. Yet, judging from progress now being made, it will be many years before any appreciable percentage of dairy calves are sired by good proved bulls.

"For instance, the New York State Dairy Herd Improvement Association Report for 1932 shows a total of 34,281 cows tested, yet only 134 bulls proved. Of this number only 25 were alive when proved. In any event, it appears that a great number of untried young bulls must continue to be used. Every proved sire was once an untried calf, and some breeder had to take a chance in proving him. It is a tragedy and a severe loss to the industry that so many of these prospective herd improvers are failures when proved. Even when a young bull does prove out and effects an improvement in the herd, he is too often followed by another young sire that immediately reduces production to its original low level, and the actual improvement to the breed is negligible."

In June 1932 the American Jersey Cattle Club adopted a classification for bulls called "Tested Sires." To qualify, the bull had to have at least ten officially tested daughters with minimum lactations of 270 days in length. The results of this study are based on the data thus provided, and it must be noted that the yields are computed in pounds butterfat and not as total yields of milk.

Of the 729 sires, 385 were out of recorded dams. The correlation between the dam's records and those of her son's daughters was $+0{\cdot}331 \pm {\cdot}031$. This is rather higher than has been found in other investigations. The correlation between the yields of the sire's daughters and the yields of his son's daughters was as high as $+0{\cdot}558 \pm {\cdot}055$. This shows that in the selection of a dairy bull for high butterfat yield, it is more important that the young bull should be out of a proven sire than out of a high-yielding dam.

The writer also studied the relationship between the effect of the two grandsires of a young bull. If the worth of the two grandsires was to be assessed by the yields of their daughters, he found that the maternal grandsire had a considerably greater effect upon the yields of the daughters of his grandsons than had the paternal grandsire. The correlation between the paternal grandsire's daughters and grandson's daughters was $+0{\cdot}250 \pm {\cdot}036$. The correlation between the maternal grandsire's daughter and his grandson's daughters was $+0{\cdot}427 \pm {\cdot}036$. This may be taken as a possible indication that sex-linked factors are involved.

The results may be summarised as follows :—

In studying the ancestry of a bull calf the records of the sire's daughters are considerably more valuable than is the record of the dam alone. On the evidence submitted, the records of the daughters of the maternal grandsire are more closely related to the production of the grandsons' daughters than are the records of the daughters of the paternal grandsire.

It would appear that if a cow has a production record herself, and if she has two or more tested daughters, and if in turn her sire has a number of tested daughters, the sum of this information gives a good index of her germinal composition. This combined information is necessary to evaluate accurately a cow's transmitting ability.

The Bull Index Problem. *J. L. Lush.* 1933. *Journ. Dairy Science, 16*, 501-522.—There would appear to be no end to the amount that can be written concerning this Bull Index problem. It is, however, to the author's credit that he has brought some additional information to bear, and has also focused attention on certain aspects which hitherto there has been a tendency to neglect. Dealing with the problem of an Index based on the average of the yields of the daughters alone, Dr Lush states that if each herd could be regarded as a random sample of the cows in the breed, the average merit of the herds would not be exactly the same, yet the differences would not be important. However, he lays some stress upon the phenomenon of "nicking." The more important this is, the more important it is to line breed and to stay within certain family lines.

Concerning the number of daughters required, Dr Lush also states that the records of more than three daughters give more information than can possibly be obtained from the completest study of the pedigree of the dairy bull. Increasing the number of daughters does not decrease the error due to unknown or uncorrected differences in herd environment, or from the differences in the average merit of the dams. It is undesirable to publish any sire index based on fewer than five daughters, and more than this number is required if the dams are not taken into account.

Discussing the various indexes, the writer draws attention to one by Norton, which

is outwardly similar to the equal parent index, except that it takes into account the average amount of regression toward the mean of the breed which has occurred in the past, without bothering to inquire into the causes of that regression.

The index which the writer recommends is the equal parent index. Since the offspring tend to average midway between the parent's inheritance, the simplest index is to add to the daughter's average the increase of the daughters over their dams. He states that the greatest weakness is in the possibility that daughters and dams may not have been tested under the same conditions, and that a minor weakness is its failure to utilise information about daughters out of untested dams. He does not discard the daughter average as useless as an index. He states that it is the first step on which the usable sire indexes are all built. However, it neglects differences in the merit of the dams, and is rather sharply affected by herd environment. No index will give infallible results. The sources of error cannot be absolutely eliminated.

Lactation in a Barren Heifer. *I. Johansson and M. H. Knudsen.* 1933. *Journ. Dairy Sci., 16*, 523-528.—In the cross-breeding herd of the Genetics Department of the University of Wisconsin a barren heifer, the first cross of a pure-bred Jersey and by an Aberdeen Angus cow, was born on 30th January 1914. She was bred for the first time on 23rd March 1916. Before the end of November 1916 she was bred fifteen times at irregular intervals, and these continued in February and April, and were then discontinued till January 1918, from which time she was mated once or twice almost every month during the year. Artificial insemination was attempted in 1919, and the heifer was slaughtered in June 1920.

In the summer of 1916 the heifer was in the same field with other heifers and calves, and it was observed that some of the animals had acquired the habit of sucking each other. The udder enlarged, and it was quite evident that the calves were getting milk. In January 1917 she was separated from the other animals and milked by hand, at which time she gave five pounds of milk. In 630 days she produced 501 gallons at an average fat percentage of 4·39. The Babcock test was made once a week on composite samples taken at each milking. During the first six months of lactation there was a steady increase in the daily yield of milk, followed by a subsequent decline. The milk was normal in every respect. Physiological aspects of this case and of those previously reported are discussed.

The Yield and Composition of Milk from Aberdeen Angus Cows. *L. J. Cole and I. Johansson.* 1933. *Journ. Dairy Sci., 16*, 565-582.—Seven Aberdeen Angus cows were compared under similar conditions of environment and husbandry with Jersey and Holstein-Friesian cows. On an average the cows produced 310 gallons of milk at 4·1 per cent. butterfat, but a considerable range of variation round the average was found to exist. The fat and protein content of the milk is a little lower than in the milk from two Jersey cows kept under similar environmental conditions. The rate of milk secretion is, on an average, lower in the Aberdeen Angus cows than in the Jerseys and Holstein-Friesians, and the lactation period is shorter. Some of the Aberdeen Angus cows attained as high a monthly yield as low- or medium-producing Jerseys, and also showed fairly good persistency of production. One heifer gave as low a yield as 75 gallons in 103 days. Other records from this heifer are 87 gallons in 110 days and 103 gallons in 184 days. The highest yield recorded is 675 gallons in 551 days from a heifer which in the next lactation gave 371 gallons in 191 days. Probably the best record is 523 gallons in 325 days.

There is a general discussion on the yields of low-yielding cows.

A Lethal Character in Cattle. *F. B. Hutt.* 1934. *Journ. Heredity, 25*, 41-46.—In three herds of Holstein cattle there occurred an abnormality affecting the muscle contracture of the calves. Five abnormal calves were found, and they were all sired by the same bull. The abnormality was so extreme that only two could be delivered entire, and then only with great difficulty. The calves were alive at full term, but had caused distress to their dams before the end of the gestation period. At birth the head was drawn up towards the back, apparently by contraction of the cervical muscles, and the neck was extremely rigid. The fore and hind limbs were folded and almost wrapped around the body. All five calves were the same.

A curious point concerning these calves is that in the year before they were born their sire had been injured by getting a chain embedded in his neck. After the wound healed the neck was stiff for a long time. The owner stated that when the bull was taken out for service the painful condition and stiffness in the neck seemed even more pronounced than at other times. Accordingly when five calves were born exhibiting, among other complications, extreme rigidity of the neck, it was not unnatural that the owner should ascribe the abnormality of the calves to the injury of the sire. This interpretation seemed all the more likely because, although the bull was nearly six years old, his progeny had all been normal prior to the injury to his neck, which had occurred in his fifth year.

Further investigation showed that this injury to the sire was a mere coincidence, and that the clue to the story lay in the pedigrees of the dams, three of which were sired

by the same bull, and had thus been bred back to their sire. The fourth was a half-sister to the bull, but out of a different dam. The paternity of the fifth was not definitely established, though there is reason to believe that she also was sired by this same bull, and thus, like the first three, was mated back to her own sire. It is therefore obvious that the condition is hereditary. Nor could it have appeared earlier, since its manifestation depended on the bull being mated to his own daughters.

A similar condition has recently been reported in Norway. It has, however, never been reported in this country. Should it occur it will be imperative to eliminate from the breeding herd both the parents of an abnormal calf of this nature.

A parallel abnormality has been noted both in sheep by Roberts, and in pigs by Hallqvist.

Recessive Coloration in Dutch Belted Cattle. *R. B. Becker.* 1933. *Journ. Heredity, 24*, 283-286.—This is a short note concerning a Dutch belted cow in the herd of the Florida Experiment Station. This confirms previous work that the belt behaves as a simple dominant to self-colour, and that black is dominant to red.

Horses

Twins in Horses. *B. J. Errington and W. L. Williams.* 1933. *Cornell Veterinarian*, 354-361.—This paper deals primarily with the physiological aspect of the placentation of equine twins, with particular reference to a pedigreed Percheron mare that was foaled in May 1929, bred in June 1932 and produced twins 328 days thereafter. One of these twins was a dwarf, while the other was a normal colt weighing only 91 lb. The dwarf weighed 57 lb. and was produced two hours after the normal foal. The combined weight of the twins was 148 lb. as compared to their dam who weighed 157 lb. at birth. It is highly probable that the dwarf had remained alive until near the date of expulsion. The granddam of the mare in the year 1927 expelled dead twins at 320 days, weighing respectively 55 lb. and 5 lb.

It is well known that the mortality of equine twins enormously exceeds that observed in any other mammal. One of the writers has recorded that in one year in a stud of twenty-six pregnant mares there were six twin pregnancies, and that as a rule twinning mares have mostly failed to breed again. There are, however, exceptions. Every horse-breeder knows of one or two cases where the twins have been born alive and their foals have been raised.

As a rule equine twins are grossly unequal in size, far more so than is the case in any other known species. The reason for this can be explained from the study which the authors have made. In technical language it is accounted for as follows :—

"The invaginating ovum, deprived of adequate endometrial contact, inevitably becomes dwarfed and its defective nutritive supply lowers its resistance and endangers its health and life. Without chorionic fusion, as in ruminants, the invaginating ovum cannot obtain parasitic nutrition from its enveloping mate."

Individuals of equine twins show wide variations in their power to resist disease. In ruminants if one of a pair of twins dies, the other frequently perishes. Since equine twins possess separate chorions, they do not commonly die simultaneously.

Available data indicate that most equine twins are males, perhaps in the neighbourhood of about 150 males to 100 females, but the ratio of abortions in males, along with early deaths, serves to equalise the sex ratio and may end, when the foals are a few days old, in an excess of fillies.

Poultry

Inheritance of Albinism in the Domestic Fowl. *D. C. Warren.* 1933. *Journ. Hered., Volume* 24, 379-383.—An Albino hen is now reported for the first time. The birds are, of course, white with pink eyes. The plumage and eye colour are associated with each other, and in the matings made there was no appearance of segregation. As in other animals albinism behaves as a simple recessive to normal colour. This adds a fourth member to the series of whites in the domestic fowl, the others being the dominant white which is characteristic of the White Leghorn breed, and the two recessive whites which are independent in their action. One of these is characteristic of the Silky White Bantam, and appears to be limited to the Bantam varieties. The other is the white of the Dorking breed, and is the same factor which is responsible for the white colour of the White Plymouth Rock and the White Wyandotte.

This Albino factor is clearly expressed in a day-old chick, since the brilliant pink eye readily distinguishes the Albino from the normal, which has black eyes at hatching. The Albino, however, is not a vigorous bird, because the poor eyesight rather seriously interferes with its existence.

Linkage Tests in Poultry. *W. Landauer.* 1933. *Journ. Heredity, 24*, 293-294.—The author produces data which suggest the existence of linkage between the genes of rump-

lessness and frizzled plumage. He has been able to obtain no evidence that there is any linkage of the genes for rumplessness and crest.

GENERAL

Sex Control Again. *L. J. Cole and I. Johansson.* 1933. *Journ. Heredity*, *24*, 265-274.—"Among perennial announcements that occur, particularly in the popular press, are the discovery of the 'germ' of cancer, cures for tuberculosis, and methods for the control of sex. If cancer is caused by a germ, it no doubt will sometime be discovered; it is not improbable that a specific cure for tuberculosis may some day be found; and sex of offspring will be under control just as soon as someone discovers a method of effectively separating the male- and female-producing spermatozoa, thus determining which shall fertilise the egg."

So state the authors in the opening sentences of a paper to which they have been provoked by a number of announcements in the daily press of the United States. The latest vogue in methods for the determination of sex is that, according as the vagina is more alkaline, so is there a greater chance for males to be produced. This has led to the washing of the vagina with a weak solution of sodium bicarbonate, and, when females are desired, the use of lactic acid. This theory does not stand any more critical examination than do many previous theories of sex control. The present writers conducted a limited experiment with swine to test the possible effects of alkalinity on sex ratio. They were unable to effect the sex ratio, but they did decrease the fertility of the sows.

The outstanding fact with regard to sex determination is that, in mammals there are regularly two types of spermatozoa. One of these types bears an X-chromosome and the other bears a Y-chromosome. Both types are normally produced in equal numbers. The eggs are all of one sort, each with an X-chromosome. The sex of an individual depends on whether the egg is fertilised by an X-bearing or a Y-bearing spermatozoon. In the former case the result is a female and in the latter case a male.

Countless theories of sex determination and of sex control have been proposed, but they have done more credit to the imagination of the proposers than to their scientific acumen. At the same time it must be recognised that the sex ratio both in man and animals is subject to variation, and that little is known as to the cause of these variations. There is no doubt that some day the sex will be brought under control. But that day has not yet arrived.

ANIMAL NUTRITION.

Palability of different Grasses and Clovers with Free-choice Grazing. Beobachtungen über die Schmackhaftigkeit verschiedener Gräser und Kleearten bei freiem Weidegang. *A. Tiemann and G. Müller. Arch. f. Tierernahrung u. Tierzucht*, 1933, *9*, 253-265. (*Animal Husb. Res. Inst., Tschechnitz.*)—Observations were made during free-choice grazing trials on 14 different grasses and 5 clovers, the test animals used being cows, horses, pigs, sheep, and goats. Cows and horses showed a special liking for grasses, whereas pigs and sheep preferred clovers. The preferences of the different species of animals for the individual grasses or clovers are noted.

Comparative Crop and Feeding Experiments with Cabbage and Beet. Vergleichende Anbau- und Fütterungsversuche mit Futterkohl- und Runkelrübensorten. *G. Rothes and W. Meinhold. Landwirtsch. Jahrb.*, 1933, *78*, 81-102. (*Agric. Coll. Bonn-Poppelsdorf.*)—Several varieties of kale were compared with beet in respect of yield and feeding value. Numerous protocols are given. In general the starch value per unit area was higher for beet, but the protein lower. The desirability of substituting kale for beet is determined by numerous local conditions. Growing of both crops is often advisable. The taste and odour of milk were not adversely affected even with very high (50 kg.) rations of kale, and the colour and texture of butter were improved.

Lupins as a Silage Crop for Light Soils. Die Lupine als Gärfutterpflanze fur leichten Boden. *Tiemann and Rehm. K. Richter and K. E. Ferber.* 2. *Verfütterung von Lupinensilage.* (Feeding lupin silage.) *Die Futterkonservierung*, 1933, *4*, 19-25, 26-33. (*Inst. Animal Breeding, Tschechnitz, Kreis Breslau.*)—For use as a mixed crop with oats to be harvested for seed or for silage, red and blue lupins do best. The best mixture is one of 120 kg. lupin and 50 kg. oats per hectare. The crop should be harvested before the oats have set seed and while the lupins are in flower, but showing few pods. A good silage with chiefly lactic acid fermentation resulted with lupin oat mixture or fodder lupins alone.

The digestibility coefficient of ensiled fodder lupins was determined with wethers. Lupin silage contains 2·15 per cent. digestible protein and 4·9 kg. starch equivalent per 100 kg. Fed to milk cows with laxative feedstuffs the silage was well utilised, and no harmful effects were observed.

Possibility of using Potato Pulp for Feeding. Die Möglichkeiten der Verwendung von Kartoffelpülpe als Futter. *Dr Lüthge. Ztschr. f. Schweinezucht,* **1933, *40*, 640-642.** (*Halle a.S.*)—Potato pulp is a by-product obtained in the manufacture of potato starch. It has a digestibility of only 72 per cent. and contains no protein. It may form part of the rations fed to cattle, pigs, cows, and horses if the ration is properly balanced by the nclusion of easily digestible foods rich in protein.

Wet versus Dry Beet Pulp for Milk Production. *H. O. Henderson and C. E. Teague. Journ. Dairy Sci.,* 1933, *16*, 363-368. (*West Virginia Univ., Morgantown.*)—Experiments conducted with 26 cows showed that there was no appreciable difference in the value of wet and dry beet pulp as regards production, palatability, maintenance of body weight, or amount of water consumed.

Treacle as a Supplemental Concentrate. *Sci. Rep. Govt. Agric. Chem., Coimbatore,* 1932-33, 27.—No differences were observed either in milk yield or live-weight increase of cows as a result of feeding treacle in addition to a full dairy ration.

The Nutritive Value of Proteins for Milk Production. 1. A Comparison of the Proteins of Beans, Linseed, and Meat Meal. *S. Morris and N. C. Wright. Journ. Dairy Res.,* 1933, *4*, 177-196. (*Hannah Dairy Res. Inst., Ayr.*)—Compared with the proteins of bean meal, the proteins of linseed contain a relatively small quantity of lysine, while those of meat meal are seriously deficient in tryptophane. The proportion of these two amino-acids in milk is high. The milk yields on the two deficient rations (linseed and meat meal) were significantly lower than those on the adequate ration (bean meal). There was evidence of a storage of reserve nitrogen which can be utilised for milk production when the food protein is inadequate. The nitrogen wastage (urine) was low during bean meal feeding, high with linseed, and intermediate with meat meal. With reference to the technique of metabolism experiments, it is suggested that 0·6 lb. protein per 1000 lb. live weight for animals in a resting state is too high. From their data the authors calculate that, under the conditions noted, the biological values for milk production of the mixed rations containing bean meal, meat meal and linseed meal were 59, 55, and 46 respectively.

Pig-Feeding Experiments with Dried Skimmed Milk. Schweinemastversuche mit Magermilchpulver. *E. Crasemann. Jahresber. d. Landwirtsch. Schule Strickhof, Zürich,* 1932-33, 92-103.—Fish meal and dried skimmed milk were fed separately as protein supplements to a ration of barley, bran, and sharps. Gains in weight were small, and the skimmed milk group was superior. In a second experiment fish meal was compared with a mixture of dried skimmed milk, earthnut cake, soya-bean meal and bone meal. In this mixture the cost of protein was the same as in fish meal. Daily weight increases were again small, but the mixture was superior to fish meal. Costs per unit gain were the same in both groups.

Potato Flakes, a Valuable Home-produced Feed for Fattening and Breeding Pigs. Kartoffelflocken, ein hochwertiges deutsches Futtermittel für Mast- und Zuchtschweine. *H. Lüthge. Ztschr. f. Schweinezucht,* 1933, *40*, 605-606. (*Halle a.S.*)—The German method of feeding potatoes, dried potatoes, swedes, lucerne, etc., to pigs is described. These foods are fed to appetite in addition to a daily fixed quantity of a basal ration high in protein. As an alternative a number of rations, in which potato flakes are included, are given for pigs of different weights.

The Role of Salt in Poultry Nutrition. 1. Salt in the Nutrition of the Chick. 2. Salt in the Nutrition of the Laying Hen. *J. H. Prentice. Journ. Minist. Agric., N. Ireland,* 1933, *4*, 72-91, 92-104.—It is concluded from tests extending over three years that the only minerals essential for satisfactory returns, low mortality, and efficient utilisation of food, during both growth and egg production, are common salt and lime. Of the former not more than ½ per cent. is necessary.

STATISTICS

PRICES OF AGRICULTURAL PRODUCE, FEEDING STUFFS, AND FERTILISERS IN DECEMBER 1933, AND JANUARY AND FEBRUARY 1934.

LIVE STOCK: Monthly Averages of Prices at certain representative Scottish Markets.

(Compiled from Returns received from the Department's Market Reporters)

Description	December 1st Quality	December 2nd Quality	December 3rd Quality	January 1st Quality	January 2nd Quality	January 3rd Quality	February 1st Quality	February 2nd Quality	February 3rd Quality
FAT STOCK:—									
*CATTLE—	per cwt. s. d.	per cwt. s. d.	per cwt s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt s. d.	per cwt. s. d.	per cwt. s. d.
Aberdeen-Angus ..	46 10	42 0	40 0	46 9	42 3	40 5	45 9	41 7	39 0
Cross-bred (Shorthorn)	42 11	38 5	28 1	43 9	39 10	31 8	42 7	39 1	32 2
Galloway	43 0	39 0	..	42 1	39 1	..	40 9	37 11	..
Ayrshire	39 0	30 10	26 1	40 0	34 9	29 5	39 7	34 7	28 9
Blue Grey	48 1	44 5	40 0	49 2	45 5	40 10	47 2	43 0	39 0
Highland	..	36 0	..	34 0	..	..	..	..	..
	per lb d.	per lb d.	per lb. d.	per lb. d.	per lb d.	per lb. d.	per lb. d.	per lb d.	per lb. d.
†VEAL CALVES	12	3	..	12	3	..	14	3¼	..
†SHEEP—	Hoggs under 60 lb. per lb. d.	60 lb. and upw'd. per lb. d.	Ewes per lb. d.	Hoggs under 60 lb. per lb. d.	60 lb. and upw'd. per lb. d.	Ewes per lb. d.	Hoggs under 60 lb. per lb. d.	60 lb. and upw'd. per lb. d.	Ewes per lb d.
Cheviot	10	8¾	6	10	9¼	6	10	9¼	6¾
Half-bred	9¼	7¾	5¼	9¼	8¼	5¾	9½	9	7
Blackface	10¼	9	6¼	10¼	9¼	6½	10	9¼	7
Greyface	9½	8½	6	9¾	8¾	6¼	10	9¼	6¾
Down Cross	9¾	9¼	5	9½	9¼	5¾	9½	9	7
†PIGS—	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.
Bacon Pigs	8 11	8 0	..	9 1	8 3	..	9 4	8 6	..
Porkers	9 10	8 10	..	10 3	9 3	..	10 5	9 6	..

* Live weight. † Estimated dressed carcase weight.

Live Stock: Monthly Averages of Prices (per head) at certain representative Scottish Markets—(*continued*).

Description	December 1st Quality	December 2nd Quality	December 3rd Quality	January 1st Quality	January 2nd Quality	January 3rd Quality	February 1st Quality	February 2nd Quality	February 3rd Quality
STORE STOCK:—									
Cattle—									
Aberdeen-Angus:	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.
Yearlings	14 8	11 0	7 10	14 11	11 11	..	14 10	11 13	10 0
Two-year-olds ..	17 12	15 0	..	18 9	15 3	..	18 0	14 16	10 10
Cross-bred (Shorthorn)									
Yearlings	13 9	9 12	..	13 14	10 3	..	13 10	10 10	..
Two-year-olds ..	16 8	13 10	..	17 8	13 16	..	17 7	13 14	..
Galloway:									
Yearlings	10 12	9 5	..	12 12	10 8	..	12 3	10 6	..
Two-year-olds ..	..	..	..	15 0	14 5	..	..	13 5	..
Ayrshire:									
Yearlings	..	..	..	..	..	..	..	..	..
Two-year-olds ..	..	..	..	..	..	..	..	..	..
Blue Grey:									
Yearlings	..	..	..	..	..	..	11 0	10 0	8 0
Two-year-olds ..	..	..	..	..	..	..	14 0	12 0	10 0
Highland:									
Yearlings	..	..	..	..	..	..	..	..	..
Two-year-olds ..	..	..	..	..	..	..	..	..	..
Three-year-olds ..	..	..	..	..	..	..	..	..	..
Dairy Cows—									
Ayrshire:									
In milk	26 17	20 4	16 11	25 0	18 6	14 10	23 17	17 13	14 1
Calvers	27 9	20 18	16 2	25 3	19 9	15 1	24 8	18 14	14 17
Shorthorn Cross:									
In milk	27 8	20 11	19 10	25 17	19 8	18 5	25 7	18 16	18 0
Calvers	26 17	18 18	18 0	24 4	18 2	16 1	24 12	17 11	15 11
Sheep—	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Cheviot Hoggs ..	..	..	..	33 1	23 0	..	25 7	22 2	..
Half-bred Hoggs ..	33 5	24 2	..	32 1	25 10	..	35 11	27 11	..
Blackface Hoggs ..	24 9	19 3	..	21 5	17 0	..	23 8	17 8	..
Greyface Hoggs ..	35 5	28 5	..	34 6	28 5	20 0	35 0	27 10	27 3
Down Cross Hoggs	37 6	32 0	..	37 11	32 0	..	41 0	36 0	..
Pigs—									
(6 to 10 weeks old)	30 2	19 1	..	32 6	20 6	..	34 7	22 5	..

DEAD MEAT: Monthly Average Prices at Dundee, Edinburgh, and Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

DESCRIPTION	QUALITY	DECEMBER Dundee	DECEMBER Edinburgh	DECEMBER Glasgow	JANUARY Dundee	JANUARY Edinburgh	JANUARY Glasgow	FEBRUARY Dundee	FEBRUARY Edinburgh	FEBRUARY Glasgow
BEEF:—		per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.
Home-fed—										
Bullock or Heifer ..	1	7⅛	6⅞	8⅝	7⅝	7½	8¾	7½	7	8¼
	2	6¼	..	7¼	7	..	7½	7	..	7⅜
Bull	1	5⅜	4½	5½	5½	5⅜	6	5½	5¼	6
	2	4¾	..	4¾	5	..	5⅜	5	..	5½
Cow	1	4½	4⅜	5	4⅞	5¼	5½	4¾	5	5½
	2	4	..	4	4⅜	..	4½	4¼	..	4⅜
Irish—										
Bullock or Heifer ..	1	..	..	6⅞	..	..	7½	..	..	7½
	2	..	..	6⅛	..	..	6½	..	..	6½
Argentine Frozen—										
Hind Quarters ..	1	4	4	..	4	4	..	4⅛	4¼	..
	2	..	3¼	..	..	3⅜	..	..	3⅝	..
Fore ,, ..	1	3⅜	3⅜	..	3½	3¼	..	3½	3¼	..
	2	..	2¾	..	..	2¾	..	..	2⅞	..
Argentine Chilled—										
Hind Quarters ..	1	6⅜	6⅝	6⅛	6½	6⅞	6½	6½	6⅜	6¼
	2	..	5¾	5⅜	..	5¾	5½	..	5⅝	5⅛
Fore ,, ..	1	4⅛	4¼	3⅞	4⅛	4⅛	3⅞	4⅛	4⅛	3⅞
	2	..	3⅜	3⅝	..	3½	3⅝	..	3⅝	3¾
Australian Frozen—										
Hind Quarters ..	1	..	..	3⅜	..	..	3⅝	..	..	3¾
	2	..	..	..	..	..	..	..	..	..
Crops	1	..	..	3⅛	..	..	3	..	..	2⅞
	2	..	..	..	..	..	..	..	..	..
New Zealand Frozen—										
Hind Quarters ..	1	.	..	3¼	..	..	3½	..	..	3⅝
	2	..	..	..	..	..	..	..	..	..
Fore ,, ..	1	..	..	2⅞	..	..	2¾	..	..	2¾
	2	..	..	..	..	..	..	..	..	..
MUTTON:—										
Hoggs, Blackface ..	under 60 lb.	9½	8½	8⅞	9⅞	8¼	8⅞	9⅜	8	8⅝
	60 lb. & over	9	..	8⅜	9	..	8⅜	8⅞	..	8⅜
,, Cross ..	under 60 lb.	9½	8½	8⅞	9⅞	8¼	8⅞	9⅜	8	8⅝
	60 lb. & over	9	..	8⅜	9	..	8⅜	8⅞	..	8⅜
Ewes, Cheviot ..	1	..	4⅞	6	..	5⅞	6¼	..	6⅛	7⅛
	2	..	..	5½	..	..	6	..	..	6¾
,, Blackface ..	1	6½	4⅞	6	6½	5⅞	6¼	6⅞	6⅛	7⅛
	2	5½	..	5½	5⅞	..	6	6⅜	..	6¾
,, Cross	1	4½	4⅞	6	4⅞	5⅞	6¼	5¼	6⅛	7
	2	4	..	5½	..	..	6	..	..	6¾
Argentine Frozen ..	1	..	..	3½	..	..	3½	..	..	3⅝
	2	..	..	..	..	..	..	..	..	..
Australian ,, ..	1	..	5½	3½	..	5⅝	3⅝	..	5⅝	3⅞
	2	..	4⅜	..	..	4¾	..	..	4⅞	..
New Zealand ,, ..	1	..	..	4¾	..	..	4⅞	..	..	5
	2	..	..	3½	..	..	4	..	..	4¼
LAMB:—										
Home-fed	1	..	..	9½	..	..	9¼	..	..	9¼
	2	..	..	9¼	..	..	9	..	..	9
New Zealand Frozen	1	..	7½	7⅜	..	7⅞	7¼	..	7⅝	7
	2	..	6⅞	..	..	7¼	..	..	7¼	6¾
Australian ,, ..	1	..	..	6½	..	..	6½	..	..	6⅛
	2	..	..	..	..	..	..	..	..	..
Argentine ,, ..	1	..	..	6½	..	..	6½	..	..	6⅛
	2	..	..	..	..	..	..	..	..	..
PORK:—		per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.
Home-fed	1	84 0	84 0	78 9	84 0	89 10	84 0	92 2	88 8	84 0
	2	56 0	..	68 10	48 6	..	72 4	53 8	..	72 4
Imported	1	..	..	56 0	..	..	56 0	..	..	56 0

Kilmarnock, Lanarkshire, and Glasgow

(*Compiled from Returns received from the Department's Market Reporters*)

Description	Weight per 120	Quality	Dec.	Jan.	Feb.
	lb.		s. d.	s. d.	s. d.
Aberdeen—					
Country .. .. per doz.	..	1	1 9	1 3	1 0
		2	1 8	..	..
Duck .. .. „	..	1	1 9	1 4	1 0
Kilmarnock—					
Country .. .. per doz.	..	1	1 10	1 6	1 4
Lanarkshire—					
Country "Standard" per doz.	..	1	2 2	1 8	1 5
Glasgow—					
Country .. .. per doz.	..	1	1 9	1 6	..
	..	2	1 5	1 3	..
British .. .. per 120	17	..	19 5	16 2	13 11
	15½	..	17 5	14 9	12 6
	14	..	..	13 2	..
„ (ungraded) „	..	1	..	14 7	12 4
Northern Ireland „	17	..	20 4	15 11	12 9
	15½	..	18 7	14 8	11 8
„ (Duck) .. „	..	1	16 6	14 10	11 10
Irish Free State .. „	16	..	19 2	14 9	11 1
	15	..	18 3	14 3	10 8
„ "Medium" „	..	..	..	12 6	9 9
„ (Cold Stored) „	..	1	10 7	9 11	..
	..	2	9 3	9 10	..
„ (Duck) „	..	1	16 0	14 2	11 9
Australian .. .. „	16	..	13 8	..	..
Canadian (ungraded) „	..	1	9 11	..	..
Chinese („) „	..	1	..	9 3	8 10
	..	2	..	7 11	8 1
Danish .. .. „	15½	..	15 9	12 6	10 3
	14	..	..	10 4	9 5
„ (Cold Stored) „	..	1	9 8	..	..
„ (Pickled) .. „	..	1	9 6	..	..
Polish, Blue .. „	..	1	..	6 11	..
„ Red .. „	..	1	..	5 5	..
„ (others) .. „	..	1	7 5	..	6 11
	..	2	6 10	..	..
Swedish .. .. „	15½	..	..	..	10 4
	14	..	..	9 10	..
Norwegian .. „	15½	..	..	11 8	..
	14	..	..	9 10	..

Prices (per cwt.) at Glasgow.

Description	Quality	Dec.	Jan.	Feb.
		s. d.	s. d.	s. d.
Butter—				
Australian	1	76 0	71 2	74 3
Danish	1	116 0	94 7	96 0
„ (unsalted)	1	119 0	97 7	99 0
New Zealand	1	76 3	73 2	76 0
„ (unsalted)	1	79 6	76 0	79 0
Siberian	1	83 0	..	..
Swedish	1	101 0	83 7	78 9
Cheese—				
Cheddar	1	80 0	80 0	80 0
	2	56 0	56 0	56 0
Cheddar Loaf	1	76 0	76 0	76 0
	2	60 0	60 0	61 6
Dunlop	1	80 0	80 0	80 0
	2	49 0	49 0	49 0
Canadian	1	61 0	60 7	60 0
	2	57 0	56 7	56 0
New Zealand (Coloured) ..	1	51 0	49 7	52 9
„ (White)	1	53 6	52 2	50 0
Hams—				
Irish (Smoked)	1	132 0	138 0	152 0
	2	112 0	121 0	137 0
American (Long Cut, Green) ..	1	93 6	100 5	105 0
„ (Short Cut, „) ..	1	86 0	94 5	108 0
Canadian (Long Cut, „) ..	1	89 6	99 2	104 6
Bacon—				
Ayrshire (Rolled)	1	105 4	118 5	130 8
	2	98 0	..	120 1
English Wiltshire (Green) ..	1	86 6	99 5	112 0
„ (Dried or Smoked) ..	1	92 6	105 5	118 0
Irish (Green, Wiltshire Style) ..	1	84 0	92 5	104 0
„ (Dried or Smoked) ..	1	90 0	98 5	110 0
„ (Long Clear)	1	96 0	106 5	120 0
Canadian Sides (Green) ..	1	75 6	84 5	96 0
Danish Sides	1	84 0	92 2	104 0
Dutch (Green, Wiltshire Style)	1	94 0	93 7	112 0
Polish („ „ „)	1	88 0	..	..
Lard—				
American	1	33 6	34 0	35 0

Fruit and Vegetables: Monthly Average Wholesale Prices at Glasgow.

(Compiled from Returns received from the Department's Market Reporter)

Description		Quality	December	January	February
Fruit:—					
Apples—	per		s. d.	s. d.	s. d.
Canadian	case.†	1	9 3	11 9	11 8
"	barrel.††	1	17 9	18 8	22 2
Pears, Californian ..	case.‡‡	1	12 6	11 0	16 5
Vegetables:—					
Beet	cwt.	1	5 0	5 0	5 0
Brussels Sprouts ..	net.‡	1	‖4 2	4 3	5 5
Cabbage, Coleworts ..	dozen.	1	1 0	1 0	1 0
" Red .. .	"	1	2 5	2 7	2 8
" Savoy . ..	"	1	1 11	2 1	2 5
Carrots, British	cwt.	1	9 9	9 7	9 5
" Dutch	"	1	8 11	8 8	8 9
Cauliflowers—					
Broccoli, Cornish ..	dozen.	1	5 3	5 8	5 6
Other British	"	1	4 0	4 0	4 0
Celery	bunch.	1	1 11	1 8	1 8
Cucumbers	dozen.	1	8 0	10 0	..
Greens	bunch.	1	0 6	0 6	0 6
Leeks	dozen bunches.	1	2 3	2 1	2 0
Lettuce, Cabbage ..	dozen.	1	2 2	4 0	4 0
Onions, *Spring*	bunch.	1	0 4	0 4	0 $5\frac{1}{2}$
" *Dutch*	bag.**	1	7 11	8 1	7 2
" *Valencia* ..	case.††	1	9 8	12 2	10 9
Parsley	cwt.	1	12 0	13 2	18 0
Parsnips	"	1	9 0	9 2	9 6
Radishes	dozen bunches.	1	2 0	2 0	2 0
Rhubarb	cwt.	1	..	30 8	27 0
Spinach	stone.	1	3 2	3 10	8 0
Tomatoes, Scottish ..	lb.	1	0 6	..	..
" Canary ..	"	1	0 $3\frac{1}{2}$	0 $4\frac{1}{2}$	0 $4\frac{3}{4}$
Turnips	cwt.	1	1 11	1 9	1 9
Vegetable Marrow ..	dozen.	1	5 0	6 0	..

† 40 lb. (approx.). ‡ 20 lb. (approx.). ** $7\frac{1}{2}$ stone (approx.).
†† 9 stone (approx.). ‡‡ 46 lb. (approx.). ‖ Bag, 2 stone (approx.).

POTATOES : Monthly Average Wholesale Prices per ton at Aberdeen, Dundee, Edinburgh, and Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

Market	Quality	First Earlies £ s. d.	Second Earlies £ s. d.	Late Varieties: Red Soils: Golden Wonder £ s. d.	Late Varieties: Red Soils: Other £ s. d.	Late Varieties: Other Soils: Golden Wonder £ s. d.	Late Varieties: Other Soils: Other £ s. d.
DECEMBER							
Aberdeen ..	1	..	..	..	..	3 19 5	2 18 9
Dundee ..	1	..	2 18 9	..	..	4 6 3	2 18 9
Edinburgh ..	1	..	3 10 0	7 0 0	..	..	3 10 0
Glasgow ..	1	..	2 9 5	..	..	4 8 9	2 13 9
JANUARY							
Aberdeen ..	1	..	..	..	..	4 6 6	2 17 6
Dundee ..	1	..	2 18 4	..	..	4 5 0	2 16 6
Edinburgh ..	1	..	3 10 0	7 0 0	..	..	3 10 0
Glasgow ..	1	..	2 8 6	..	..	4 7 0	2 15 0
FEBRUARY							
Aberdeen ..	1	..	..	..	..	4 8 9	2 13 9
Dundee ..	1	..	..	..	..	4 1 3	2 12 6
Edinburgh ..	1	..	3 10 0	7 0 0	..	..	3 10 0
Glasgow ..	1	..	2 8 9	..	..	4 10 0	2 12 6

ROOTS, HAY, STRAW, AND MOSS LITTER : Monthly Average Prices per ton at Aberdeen, Dundee, Edinburgh, and Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

Market	Quality	Roots: Carrots s. d.	Roots: Yellow Turnips s. d.	Roots: Swedes s. d.	Hay: Rye Grass and Clover s. d.	Hay: Timothy s. d.	Straw: Wheat s. d.	Straw: Barley s. d.	Straw: Oat s. d.	Moss Litter s. d.
DECEMBER										
*Aberdeen ..	1	..	..	..	63 9	..	..	..	35 0	..
†Dundee ..	1	..	ø12 0	ø15 0	81 3a 71 3b	.	38 9	.	38 9	50 8d
‖Edinburgh ..	1	..	..	..	76 3a 76 3b	..	25 0	..	25 0	..
aGlasgow ..	1	..	..	..	70 0	80 0	35 0	..	35 0	31 0e
JANUARY										
*Aberdeen ..	1	..	..	..	68 0	..	..	..	37 0	..
†Dundee ..	1	.	ø10 0	ø14 8	85 0a 75 0b	..	43 0	..	43 0	52 0c
‖Edinburgh ..	1	.	..	..	80 0a 80 0b	..	26 0	25 0	26 0	..
aGlasgow ..	1	.	..	..	70 0	80 0	35 0	..	35 0	30 8e
FEBRUARY										
*Aberdeen ..	1	..	..	..	70 0	..	..	..	43 9	..
†Dundee ..	1	..		ø14 6	86 3a 76 3b	..	42 6	..	42 6	45 0f
‖Edinburgh ..	1	..	..	..	80 0a 80 0b	..	26 3	..	26 3	..
aGlasgow ..	1	..	..	..	70 0	80 0	35 0	..	36 3	30 8e

* Ex farm, loose.
† Baled straw, delivered in town.
ø Delivered in town.
‖ Bunched straw, delivered.
a Baled and delivered.
b Delivered, loose.
c Dutch moss litter, at quay.
d „ „ delivered in town.
e Home moss litter, in 1½-cwt.
f Scottish moss litter, delivered in town.

Feeding Stuffs: Monthly Average Prices per ton at Glasgow and Leith.

(Compiled from Returns received from the Department's Market Reporters)

Description	December		January		February	
	Glasgow	Leith	Glasgow	Leith	Glasgow	Leith
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Linseed Cake—						
Home	8 16 3	8 12 6	8 12 3	8 11 6	8 14 8	8 11 11
Foreign	8 9 5	8 3 9	8 11 6	8 2 6	8 14 8	..
Decort. Cotton Cake ..	7 10 0	..	7 6 0	..	7 7 6	..
Undecort. Cotton Cake—						
Egyptian (Home manufactured)	4 7 6	4 5 8	4 9 6	4 11 0	4 12 6	4 12 6
Palmnut Kernel Cake ..	7 5 0	..	7 0 0	..	7 0 0	..
Soya Bean Cake	7 0 0	..	7 8 0	..	7 5 0	..
Coconut Cake	7 12 6	..	7 5 0	..	7 5 0	..
Groundnut Cake, undecort.—						
(37 % Oil and Album.) ..	..	5 13 9	..	6 1 11	..	5 15 0
(40 % ,, ,,) ..	..	6 13 4	..	6 8 9	..	6 10 0
Maize Germ Cake, Home mfd.	6 11 3	..	6 14 3	..	6 14 1	..
Maize Germ Meal	6 7 6	..	6 13 6	..	6 15 0	..
Rice Meal	4 0 11	3 17 6	4 1 6	3 18 0	4 1 11	4 2 6
Bean Meal	7 15 4	7 10 0	7 19 3	7 9 6	8 1 3	7 8 9
Barley Meal	5 12 6	6 2 6	5 12 0	6 3 0	5 17 2	6 0 0
Fish Meal	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0	15 10 0
Maize Meal—						
Home manufactured ..	5 19 8	5 14 5	5 18 9	5 13 6	5 19 8	5 12 6
South African (Yellow) ..	5 15 11	..	5 15 0	..	5 15 0	..
Locust Bean Meal	7 10 0	6 11 3	7 12 6	6 15 0	7 12 6	6 17 6
Maize Gluten Feed (Paisley)	5 7 6	..	5 4 0	..	5 2 6	..
Maize—						
Plate	5 0 8	5 0 0	5 2 6	4 19 6	5 1 3	4 16 3
American		..	6 6 11	..	6 10 0	..
Oats—						
Home	6 0 8	5 8 2	6 7 0	6 0 6	6 16 3	6 13 9
Plate	5 13 5	5 6 3	6 0 6	5 18 0	6 10 0	6 7 6
Barley—						
Imported	4 12 6	4 14 5	4 14 3	4 13 6	4 18 4	4 15 0
Wheat—						
Home	5 13 2	4 18 2	5 15 6	4 19 6	5 16 7	5 3 9
,, (Poultry)	5 6 3	..	5 4 6	..	5 6 3	..
Imported	5 12 6	4 18 9	5 17 6	5 5 10	6 5 0	5 1 3
Middlings (Fine Thirds or Parings)	5 19 8	5 15 0	5 18 3	5 14 0	5 18 9	5 16 3
Sharps (Common Thirds)	5 19 1	5 10 0	5 19 0	5 11 6	6 3 2	5 12 6
Bran (Medium)	5 16 3	5 15 0	6 0 3	5 15 0	6 3 2	6 5 0
,, (Broad)	5 19 8	6 10 0	6 4 0	6 7 0	6 8 9	6 14 5
Malt Culms	4 15 0	4 10 0	4 15 0	4 10 0	4 15 0	4 10 0
Distillers' Mixed Grains (Dried)	..	5 15 0	..	5 18 0	..	6 0 0
Distillers' Malt Grains (Dried)	6 9 8	..	6 6 3	..	6 5 0	..
Brewers' Grains (Dried) ..	5 5 11	4 10 0	5 5 0	4 10 6	5 5 0	4 14 5
Crushed Linseed	16 0 0	..	15 14 0	..	15 10 0	..
Locust Beans (Kibbled and Stoned)	6 10 0	6 5 0	6 12 9	6 8 0	6 14 5	6 12 6
Beans—						
China	6 17 6	..	7 2 0	..	7 5 0	..
English	7 3 9	..	7 10 0	..	8 6 3	..
Egyptian	6 15 4	6 15 0	6 19 3	6 18 9	7 3 2	7 0 0
Rangoon (White) ..	5 12 6	5 10 0	5 11 11	5 13 0	..	5 15 0
,, (Red)	..	5 10 0	..	5 13 0	..	5 15 0
Persian	7 3 2	..	7 7 0	..	7 10 0	..
Pease—						
Calcutta (White)	9 0 0	..	9 0 3	..	9 5 0	..
Karachi (,,)	8 13 9	..	8 13 6	..	8 15 0	..
Feeding Treacle	4 12 6	5 3 2	4 14 6	5 2 6	4 15 0	5 2 6
Sugar-Beet Pulp	..	5 4 5	..	5 4 5	..	5 2 6
Linseed Oil, per gall. ..	0 3 6	..	0 4 0	..	0 4 0	..

FERTILISERS : Monthly Average Prices per ton at Glasgow and Leith.

(Compiled from Returns received from the Department's Market Reporters)

Description	Guaranteed Analysis	December		January		February	
		Glasgow	Leith	Glasgow	Leith	Glasgow	Leith
	%	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Nitrate of Soda *	N. 15·5	7 13 6	7 13 6	7 16 0	7 16 0	7 18 6	7 18 6
Sulphate of Ammonia (Neutral and Granular) * ..	N. 20·6	7 0 0	7 0 0	7 2 6	7 2 6	7 5 0	7 5 0
Calcium Cyanamide †	N. 20·6	7 2 0	..	7 3 0	7 3 0	7 4 0	7 4 0
Nitrochalk * ..	N. 15·5	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0
Superphosphate ..	P.A. 13·7	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6
„ ..	„ 16·0	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6
„ ..	„ 18·3	3 2 6	3 2 6	3 2 6	3 2 6	3 2 6	3 2 6
Ground Mineral Phosphate ** ..	P.A. 26	2 7 6	2 7 6	2 7 6	2 7 6	2 7 6	2 10 0
„ „ „ ** ..	„ 34	3 7 6	3 7 6	3 7 6	3 7 6	3 7 6	3 10 0
Potassic Mineral Phosphate	P.A. 18 Pot. 10	3 16 3	..	3 16 3	..	3 16 3	..
„ „ „	P.A. 18 Pot. 9	..	3 10 0	..	3 10 0	..	3 10 0
„ „ „	P.A. 18 Pot. 5	..	3 2 6	..	3 2 6	..	..
„ „ „	P.A. 20 Pot 7.5	3 10 0	..	3 10 0	..	3 10 0	..
„ „ „	P A. 21 Pot. 6	..	..	..	..	..	3 2 6
„ „ „	P.A. 21 Pot. 5	3 5 0	..	3 5 0	..	3 5 0	..
Kainit (in bags) ..	Pot. 14	3 8 6	3 2 6	3 8 6	3 2 6	3 8 6	3 2 6
Potash Salts ..	Pot. 20	4 0 0	3 12 6	4 0 0	3 12 6	4 0 0	3 12 6
„ „ ..	„ 30	5 7 6	4 15 0	5 7 6	4 15 0	5 7 6	4 17 6
Muriate of Potash (on basis of 80 per cent purity)	Pot. 50	9 5 0	8 10 0	9 5 0	8 10 0	9 5 0	8 15 0
Sulphate of Potash (on basis of 90 per cent. purity)	Pot. 48·6	10 12 6	9 15 0	10 12 6	9 15 0	10 12 6	10 0 0
Steamed Bone Flour	N. 0·8 P.A. 28	6 0 0	..	6 0 0	..	6 0 0	6 0 0
„ „ „	N. 1 P.A. 30	..	5 15 0	..	5 15 0	..	..
Bone Meal (Indian)	N. 4 P.A. 20	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0
Potassic Slag	P.A. 12 Pot. 6	..	3 10 0	..	3 10 0	..	3 10 0
Basic Slag ‡ ..	P.A. 12	2 5 0	..	2 5 0	..	2 5 0	..
„ „ ..	„ 13	2 6 0	1 19 0	2 6 0	1 19 0	2 6 0	..
„ „ ..	„ 14	2 8 0	2 1 0	2 8 0	2 1 0	2 8 0	..
„ „ ..	„ 15	..	2 3 0	..	2 3 0	..	b2 10 0
„ „ ..	„ 15·75	..	a2 10 0	..	a2 10 0	..	b2 12 6
„ „ ..	„ 16·5	..	2 8 0	..	2 8 0	..	..

Abbreviations :—N. = Nitrogen ; P.A. = Phosphoric Acid ; Pot. = Potash.

* Carriage paid, in 6-ton lots. † Carriage paid, in 4-ton lots.

** Fine grist, 90 per cent. fineness through prescribed sieve.

‡ Basic Slag :—At Glasgow—80 per cent. citric soluble and 80 per cent. fineness; f.o.r., in 6-ton lots. At Leith—Non-citric soluble; carriage paid in 6-ton lots in Mid and East Lothian.

a Citric soluble. *b* 80 per cent citric soluble; on rail, in 2-ton lots.

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AGRICULTURE IN NORWAY

JAMES GRANT, B.Sc. (Agric.)

NORWAY (excluding Svalbard) has an area of some 125,000 square miles, of which lakes and rivers occupy over 4 per cent. Of the land area of slightly under 120,000 square miles 70 per cent. is, for the most part, unproductive, there being less than 36,000 square miles of productive forest, pasture and arable land. The forest area is rather more than 27,000 square miles, and of this about one quarter is interspersed with pasture. The division of the land area according to its utilisation is as follows :—

	Per cent.
Arable land	2·19
Permanent pasture . . .	·92
Outlying pasture . . .	·36
Woodland	22·98
Other land	73·55
	100·00

The total area of arable land and permanent pasture is about 37,000 square miles, and if to this be added the outlying pasture the total becomes 41,000 square miles. The total agricultural area is, therefore, very small.

The population is sparse and located mainly along the coast. The total is scarcely 2·75 millions, or 3·3 persons per square mile of land area. The corresponding figures per square mile of productive and of arable land are respectively 11·1 and 151·0. In spite of the small agricultural area, over a third of the total population is engaged in this industry, that is, including forestry and horticulture. The percentage classification according to occupation is as follows :—

	Per cent.
Farming, gardening and forestry	33·3
Fisheries and hunting	6·1
Industrial occupations	28·8
Commercial occupations	9·2
Transport	8·9
Professional occupations	4·9
Other occupations	8·8
	100·0

If we subdivide the first group of 33·3 per cent. we find that 62·7 per cent. are farmers and smallholders, and that the total connected with agriculture forms nearly 90 per cent. of the group :—

	Per cent.	Per cent.
Farmers and smallholders	62·7	
Cottars and agricultural labourers . . .	13·3	
Others connected with agriculture . . .	13·6	
Subtotal		89·6
Garden owners, Horticulture officials and labourers		·8
Forest owners, etc.	·2	
Officials and Labourers in timber floatage .	9·4	
Forestry subtotal		9·6
		100·0

Many of the first group of so-called farmers and smallholders are, however, only part-time farmers. Norway is essentially a land of smallholdings, and many of them are too small from which to extract a livelihood. To most holdings belong forest and grassland or mountain pasture, and in many cases the forest is the main source of income. Along the coast fishing and farming are often successfully combined. Judged from the British standpoint many of the holdings are even too small to be classed as smallholdings, as will be seen from the following table (1929 statistics) giving the division of the holdings into size groups (arable land) :—

Size groups		Number of holdings	
" Dekar "	Acres	Absolute Number	Relative Number
up to 2	up to 0·5	84,382	28·28
2– 5	0·5– 1·2	29,475	9·88
5– 10	1·2– 2·5	36,141	12·11
10– 20	2·5– 4·9	49,772	16·68
20– 50	4·9– 12·3	58,282	19·53
50– 100	12·3– 24·7	24,780	8·31
100– 200	24·7– 49·4	11,441	3·84
200– 300	49·4– 73·1	2,691	·90
300– 500	73·1–123·5	1,145	·38
500– 700	123·5–172·8	169	·06
700–1000	172·8–246·9	61	·02
over 1000	over–246·9	21	·01
..	..	298,360	100·00

According to the above figures the mean area lies about the middle of the fourth group, or roughly at 3·75 acres. The first group consists of small garden plots, and many have a value as

building sites but nothing more. Omitting this group the mean area still lies in the fourth group but now nearer its upper limit—say 4·5 acres. From the statistics available it is impossible to say which exactly are farms and which are not, but the first five groups may reasonably be excluded from the farms proper. When this is done the mean area of the remainder is between 19 and 20 acres. The number of large farms is exceedingly small, there being only 21 holdings of over 247 acres.

The cultivated land is employed chiefly for the production of cereals (oats, barley, rye and wheat), of hay and green crops, and of roots, including potatoes, which are an important item in the crop production of Norway. The areas under the various main crops as percentages of the total arable land are approximately as follows :—

	Approx. Per cent.
Cereals	27
Roots and green crops	11
(of this, Potatoes 7 per cent.)	
Fallow	1
Artificial meadow	61
	100

The main arable land districts lie in the south-eastern region, along the south-west coast and around the Trondheim fjord. From the Norwegian point of view these areas are relatively very level, but actually they are, generally speaking, very hilly. Various rotations are followed in different parts of the country, but on many of the best farms a six-course shift is used, namely, cereals followed by roots and then cereals again followed by three years' grass, which is the same rotation as is commonly used in the north-east of Scotland ; with the difference that in Norway most of the first-year grass is used for hay, a practice which is seldom followed now in the north-east of Scotland.

The climate of Norway is somewhat variable, but in general may be said to be rather humid. The annual rainfall varies greatly in different parts of the country—from about 12 inches in some of the interior areas to nearly 80 inches on the west coast. In the south-eastern region the usual is about 26 inches, and in the Trondheim district about 37 inches. In most parts of the country long and hard winters followed by short though usually bright and warm summers are the rule.

With the exception of some small districts in the south-west, farm work proper can only be carried on from April or May to the end of October. Work must, therefore, be done at high pressure, and in Norway there is no such thing as an eight-hour day for anyone on the farms in this short period. For the same reason modern labour-saving implements and machinery, mostly of

American manufacture, are used as much as possible, not so much with a view to reducing the labour bill as to making the best use of the time available. In this respect many Norwegian farms, in spite of their small size, are much better equipped than the larger farms in Britain. The farms, however, are much too small to allow of efficient use being made of such devices, and the very small fields and uneven topography render their use still more uneconomic. The climate, on the other hand, makes their use almost a necessity.

In addition one must take into consideration the fact that the land is, generally speaking, very difficult to till. Tractor power is now used to a certain extent on the larger farms in the more level districts, but in most parts the land is too steep for its use. In some parts where it is even too steep to use horses for draught purposes, it is very difficult to keep the loose and stony soil in place. "In the Westland," for example, "there may be seen farms so situated that they can only be reached by ladders laid up the side of the mountain, and in many places the farms are scattered at great distances from each other, with very bad roads, or none at all, between them" (O. T. Bjanes).

Considering the technical, topographical and climatic difficulties with which the Norwegian farmer has to contend, the crop yields are better than might be expected. This has to a large extent been made possible by the results of biological research; hardy and rapidly maturing strains of crop plants, suitable and indeed necessary for the country, have been bred. The use of artificial manures, which has increased in recent years, is also in part responsible. For all crops the northern part of the country gives the lowest yields, the west and the south-eastern the highest. According to the official statistics the average yields of the main crops in 1930, calculated to cwt. per acre, were as follows :—

Wheat	14·9
Rye	15·7
Barley	16·3
Oats	16·2
Mixed Corn	16·6
Potatoes	153·1
Fodder Roots	339·6
Hay	29·8

The bulk of the crops produced is used for feed for the livestock which, in the greater part of the country, must be house fed from September or October to June. In many districts the extensive mountain grazings on which the cattle are run during the summer months contribute in no small measure to the total output of agricultural produce.

Of the livestock, cattle, kept mainly for dairying purposes, occupy by far the most important position. According to the

last official census in 1929 the total number of cattle of all ages was 1,224,182, and of these 755,135 head or 61·7 per cent. were milk cows. In the same year there were 177,169 horses, 289,039 swine, 1,533,015 sheep, and 323,677 goats. The official estimate of the total number of cattle in 1931 was 1,309,656. The following relative figures (1907 = 100) show the changes in the numbers of livestock since the War years :—

Year	Horses	Cattle	Swine	Sheep	Goats
1917	123·7	105·7	77·5	93·1	80·7
1918	128·8	96·1	67·4	100·7	79·6
1923	118·1	104·0	77·3	109·7	81·7
1924	113·6	102·4	81·1	108·4	87·5
1925	112·4	105·8	82·4	110·0	93·2
1926	112·1	110·3	98·8	114·7	98·1
1927	112·1	111·2	97·6	115·7	98·1
1928	111·5	112·2	92·0	119·0	99·2
1929	108·3	112·5	94·1	110·3	109·4
1930 [1]	108·1	115·0	110·3	114·2	112·6
1931 [1]	108·1	120·4	103·3	121·7	116·4

The numbers of cattle have been gradually but steadily increasing since the War years. As might be expected from their environment they are small and hardy in the fjord and mountain districts and slightly larger in the relatively flat regions of the country and in the south-western and Trondheim areas. The chief breeds are the Red Polls found mainly in the south-east, the Red Trondheim around the Trondheim fjord but also in fairly large numbers in the south-east, the Döle cattle in the eastern valleys, the Westland cattle in the west, and the Röros cattle in the northern districts. In addition there are occasional Dairy Shorthorns, Ayrshires, Friesians, Dutch Dairy cattle, etc. The Red Trondheim breed has been derived from crossing the indigenous breed with the Ayrshire. All the indigenous breeds are, or have been, of the dual purpose type, but now the breeding is primarily for milk production. The average yield of milk per cow is still very low, but has been greatly increased, as the following figures show :—

	Average milk yield per cow		
Year	Kg.	Gallons	Index
1865 . .	981	210	100
1875 . .	1126	241	115
1885 . .	1169	250	119
1895 . .	1275	271	130
1900 . .	1320	282	135
1905 . .	1430	305	146
1910 . .	1503	321	153
1915 . .	1530	327	156
1920 . .	1502	321	153
1925 . .	1534	327	156
1930 . .	1620	346	165

[1] Based upon official estimates.

The average yield is therefore only 1620 kg., or about 346 gallons. The official figure given as the average yield of the cows belonging to "the more advanced farmers" is 2200 kg., or about 470 gallons. In the above table the decrease between 1915 and 1920 was primarily due to lack of feeding stuffs.

There are two indigenous breeds of horses—the Gudbrandsdal or Eastland, and the Fjord or Westland. Both breeds are small and very hardy. The number of horses has been decreasing in recent years as the result of the increasing use of mechanical power, more perhaps in the towns than in the country.

Considering the extensive mountain grazings the number of sheep in the country (1,533,015 in 1929) is surprisingly small, and this in spite of the fact that it has been increasing in recent years. The native sheep are very small and few now remain pure. British breeds have been imported, notably Cheviot, but the Oxford, the Blackface and the Leicester breeds are also found. In most parts of the country the sheep are housed during the winter.

The most common breed of pigs is the English Yorkshire, but the pig stocks are generally nondescript and very mixed. The same attention is not given to the pig industry in Norway as in Denmark or Sweden.

The number of goats in the country decreased rapidly from 1875 onwards, but since 1918 it has been on the increase again, and now goats are of some importance in the dairy industry, which is by far the most important branch of farming. About half of the total income from the sale of Norwegian farm produce is derived from the dairying industry.

In such a rough and mountainous country as Norway the development of an efficient transport system presents enormous difficulties. The difficulties presented by the extremely uneven topography are further complicated by the existence of the numerous fjords which stretch their arms far inland. The comparatively flat region in the south-east is now fairly well equipped with a network of both roads and railway lines, but the rest of the country is not well served; this is especially true of continuous roads, particularly in the west. Considering the difficulties, tremendous advance has been made in providing means of transport, especially in the building of railway lines, but the available facilities are by no means adequate. In some parts there are practically no roads at all, and certainly no good roads. There are numerous isolated farms all over the country. Even in the south-east there are hardly any roads which could be called "first class" when judged by the British standard, except in the immediate vicinity of Oslo, the capital. Previously, too, information could be passed on only very slowly, but the introduction and extensive use of the telephone and radio have solved this difficulty. These instruments are now installed even in the most remote districts and are to be found in practically every farmhouse. This previous lack of means of rapid

communication, and especially the difficulties of transport which are still existent in many parts of the country, were in part responsible for the failure of some of the early attempts to organise milk marketing co-operatively.

SHEEP-MAGGOT FLIES IN SCOTLAND

Communicated by Professor JAMES RITCHIE, M.A., D.Sc.
from the Natural History Department of Aberdeen University

A New Investigation of Sheep-Maggot Flies.—The losses caused to sheep farmers through the attacks of sheep-maggot flies result from damage to the fleece, loss of condition in the sheep and rapid death if the early symptoms are not attended to, and from loss of time due to the constant attention and treatment necessary, if the attacks are to be checked. (Some data supplied by farmers on the financial losses incurred under these heads will be found at the end of this article.) In Scotland the occurrence of sheep-maggot flies was investigated in 1909 by Dr R. Stewart MacDougall; but since that time the plague has assumed such proportions in sheep-breeding countries that important investigations have recently been carried out in Australia, in South Africa, and by Dr Maldwyn Davies at Bangor, in Wales.

Conditions in Scotland vary so greatly from those overseas, and even from those in Wales, that the time seemed ripe for a fresh attack on the sheep-maggot fly problem in this country; and accordingly in 1932 a scheme was drawn up for a detailed investigation of the problem, and with the aid of a grant from the Agricultural Research Council, observations began during the season of 1933. They followed four main lines: firstly, field study of the maggot flies in relation to their attacks on sheep; secondly, trapping experiments to determine the distribution of the flies in different types of locality; thirdly, laboratory studies to determine the conditions which encouraged or limited the development of the flies: and, finally, an endeavour to discover the incidence and seriousness of the pest throughout Scotland by the circulation to sheep farmers of a questionnaire, distributed for the most part through the ready assistance of the three Scottish Colleges of Agriculture.

The Natural History Department of Aberdeen University was fortunate in having on its staff Mr F. N. Ratcliffe, who had some experience in Australia of the work being carried on there. He was responsible for the field work in connection with the sheep flocks, for the initiation of the trapping experiments, and for the observations in the laboratory. Shortly after the observations had been set going, the work was furthered, through the kindness of the Governors of the Aberdeen and North of Scotland College of Agriculture, by the valuable assistance of their advisory entomologist,

Dr Guy Morison, who took over the trapping experiments and analysed the results.

The following notes by Mr Ratcliffe, incorporating data supplied by Dr Morison, summarise the more interesting results of a first year's study of the maggot-fly problem. They must be regarded as tentative, and not as the finished results of the investigation.

Conditions in 1933; Nature of Strike, and Species Responsible.—Over the greater part of Scotland maggot-fly attack was exceedingly serious in 1933. A very large proportion of the farmers who replied to our questionnaire stated that it had been the worst year in living memory. The following special points were noted: attacks by the fly started earlier and finished later than in a normal season (there was one record of a sheep struck in November); it caused trouble on certain high pastures which had previously been relatively immune; clean lambs were struck in numbers with no apparent cause; the repeated striking of individual sheep was noticeable; and dips which had hitherto proved effective in preventing strike failed to do so in 1933. Altogether, conditions tested to the utmost the efficacy of the methods practised in dealing with the pest.

It is well known that the species responsible for maggot trouble is the small metallic bronze-green fly (the "green-bottle"), *Lucilia sericata*. The larger "blue-bottle," *Calliphora erythrocephala*, is also known to strike sheep. It is widely believed among shepherds that the greater number of the strikes in the early summer are due to the blue-bottle (whose larger maggots do not cut the skin so readily, but feed more along the surface, doing less harm), whereas the green-bottle, *Lucilia*, strikes from July and August on. This point needs verification. Our own observations indicate that it is not correct. Large maggots, which the shepherds concerned confidently stated were those of the blue-bottle, were collected from sheep in mid-June—and when bred through turned out to be those of the green *Lucilia*.

Our trapping records showed that blue-bottles (*Calliphora*) were most numerous in the early, and again in the late, summer, being much more abundant than *Lucilia* in May and June (in fact, the first record of *Lucilia* in our traps was on 7th June). It is therefore quite likely that the blue-bottle may strike sheep in May and June, though undoubtedly most of the large maggots found at this time are those of the green *Lucilia*. The difference in size of the maggots found in early and late summer seems to be due to a difference in the type of strike, and not to the fact that they belong to different species of flies.

The number and nature of the strikes throughout the season were noted in the flocks of the Rowett Research Institute. It was found that in June it was the ewes, almost without exception, which were being struck; and the maggots were always found round the base of the tail. Scouring and dirty animals only seemed

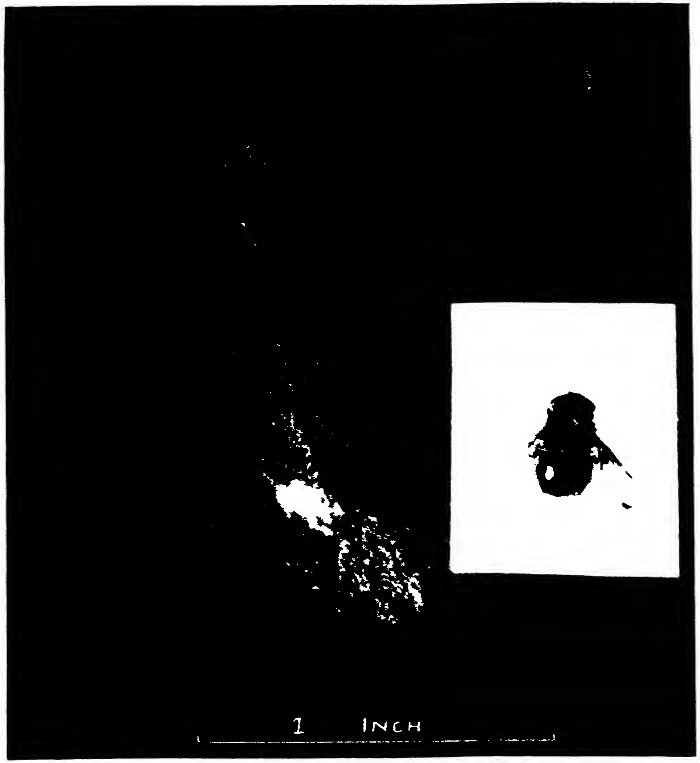

FIG. 1.—The green bottle *Lucilia sericata* with wool fibres from the fleece of a struck lamb showing an egg cluster in position

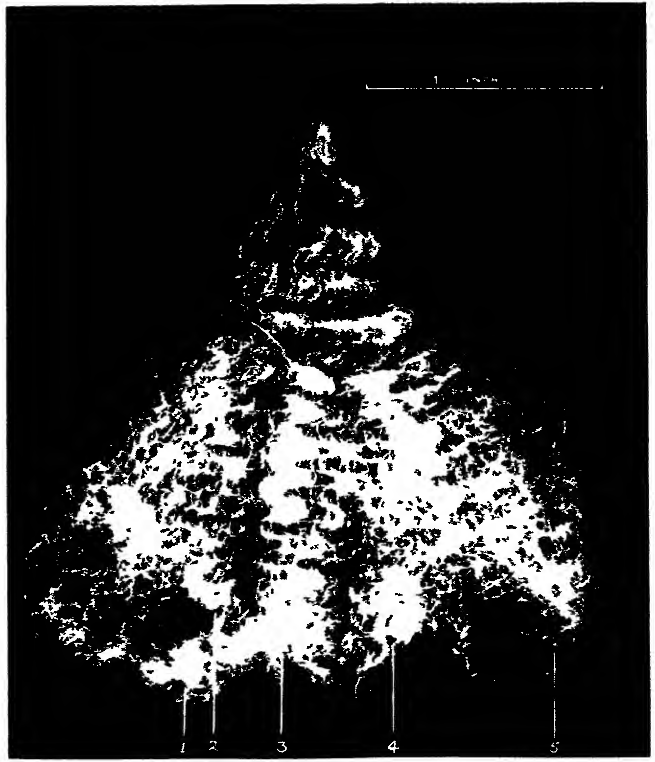

FIG. 2.—Staple of wool from a Leicester lamb showing 5 batches of *Lucilia sericata* eggs laid practically against the skin. The batches numbered 3 and 4 in the photograph were very large (both containing some thousand eggs), thus probably half a dozen flies contributed to each of them

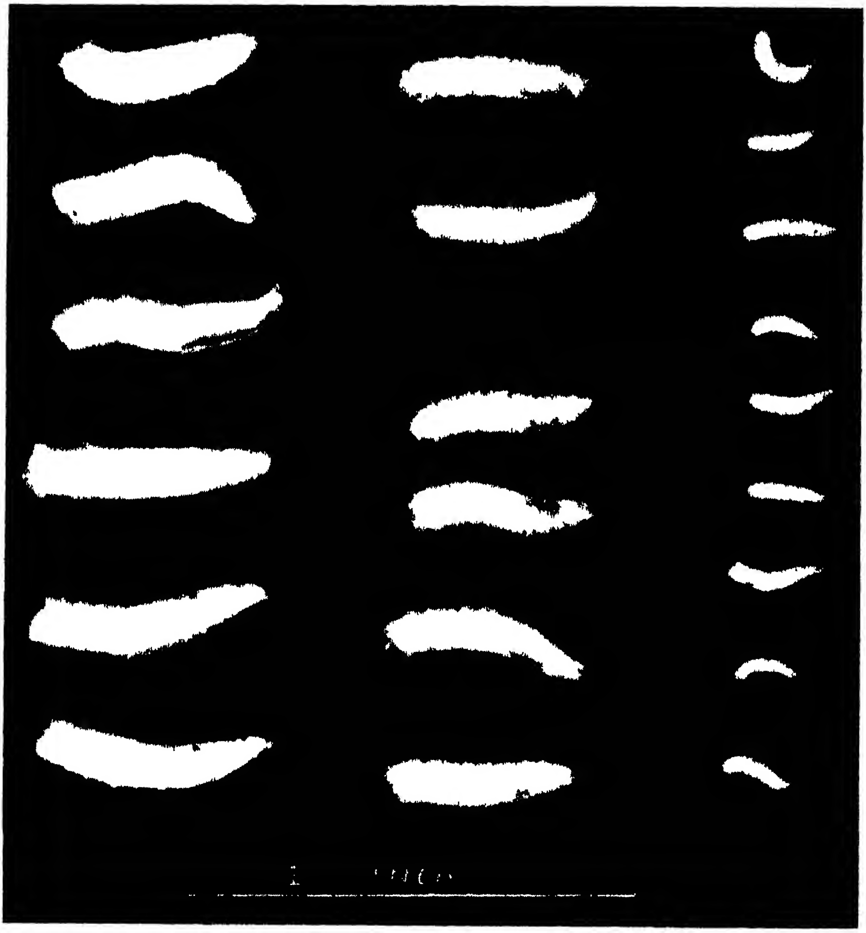

FIG. 3. Larvae of *Lucilia sericata* showing growth rates at different temperatures (from left to right 90° F., 80° F. and room temperature). The photograph was taken 8 hours after the hatching of the eggs. The maggots fed at 90° F. (which approximates to the temperature of the sheep's fleece near the skin) had attained full growth.

Fig. 4. Lamb struck on the back and treated with over-strong Carbolic dressing which has caused lifting of the wool over a large area. Paraffin has a similar effect.

Fig. 5. Typical tail strike showing the effect of unsuitable dressing which has resulted in lifting of the wool.

to be picked out by the flies. Later, as the season advanced, and the ewes were clipped, lambs were struck in increasing numbers. They were mostly struck on the body, sometimes as far forward as the neck. A favourite spot was over the ribs, just where the fore-feet would reach when the animal lay down.

The maggots we took from the ewes' tails in June were regularly larger than those taken from the bodies of lambs in August; but they all turned out to be *Lucilia sericata*. The only explanation seems to be that the tail strike is not so irritating to the sheep as the body strike of late summer, and so cases are not noticed by the shepherds so soon, in fact till the maggots have had the chance of reaching almost full size. This is not hard to understand in view of the fact that our breeding experiments showed that at the temperature of the sheep's skin maggots can reach full growth in 48 hours after hatching (see Fig. 3). There is presumably plenty of nourishment in the thick fleece of an unclipped ewe, and the maggots can get all they need feeding over the surface of the skin. In the shorter wool of the lambs, which have not a winter's accumulation of grease and sweat, there can be very little nourishment, so maggots tend to cut the skin almost at once. Naturally the sheep shows signs of uneasiness, and the strike is quickly noticed.

Farmers' questionnaire replies brought out some interesting points concerning the association of sheep-maggot flies with other animals. One considered that swallows, which he purposely encouraged, were responsible for his relative freedom from maggot trouble, as they kept down the flies. Although many blamed starlings for encouraging the pest, only one or two could produce definite evidence in the matter, having actually found batches of eggs in the immediate neighbourhood of starling's droppings on the fleece of a clean sheep. Very few farmers doubted that rabbits contributed to the spread of the pest, the warrens harbouring the flies, and providing food and breeding places in the shape of dead animals. One reply (from Kirkcudbright) specifically stated that maggot trouble became almost a thing of the past as soon as he had cleared his land of rabbits.

Some Results of Trapping Experiments.—As part of the investigation a series of specially devised traps was set up in selected localities (on the Rowett Institute pastures), and their records kept until the flies disappeared in the autumn. From the study of these records two points of interest came to light. The first, which needs confirmation, is that flies seem to follow the sheep, for the number of flies caught in a trap fell when the sheep were removed from its vicinity. This may sound obvious; but it is not so. When fifty or so sheep are in a field trapping records show that there are enough flies in the immediate neighbourhood to strike them all, and many times over; yet only half a dozen or so may be struck. Under these circumstances the reason for the flies following the sheep is not very clear.

The second point is one of direct practical importance, and throws doubt on the probable usefulness of trapping to prevent strike, a method which has often been advocated. A "carrion" baited trap (liver was used in our investigations) will catch many species of flies. A trap set in normal pasture (*i.e.* not on high hill ground, or actually in a wood) will catch the following flies *in numbers*, in addition to other species less commonly :

(*a*) two species of green-bottle : *Lucilia sericata* and *caesar* ;
(*b*) two species of blue-bottle : *Calliphora vomitoria* and *erythrocephala* ;
(*c*) two species of "flesh flies" : *Sarcophaga* and *Cynomya* ;
(*d*) a metallic blue fly : *Pollenia* sp. ;
(*e*) a dark species, slightly smaller than the house fly : *Hydrotœa dentipes*.

Of all these the two green-bottles will provide rather less than half the total number. Only one of the species, *Lucilia sericata*, strikes sheep. The other, *Lucilia caesar*, is harmless ; but it cannot be distinguished from the sheep-maggot fly without a magnifying glass (the chief difference being the number of bristles on the thorax) ; and the important point is that the harmless species outnumbers the other by about ten to one. (Our traps caught, throughout the season, approximately 23,000 *Lucilia caesar*, and only 2000 odd *Lucilia sericata.*) This means that only 10 per cent. of the green-bottles caught will be the sheep-striking species (which will therefore provide 5 per cent., or less, of the *total* catch). Thus even the farmer who realises that it is the green fly he wants to trap will be deluded into thinking that his traps are ten times as efficient as they really are.

The trap records also threw light on the haunts of the sheep-maggot fly. *Lucilia sericata* clearly dislikes the shade of woods. A trap set *inside* a beech wood caught a negligible number of flies ; while one set up hardly a dozen yards away, but outside the wood and in the open, proved to be one of our most successful traps. On the whole, it may be said that *Lucilia sericata* likes the sunshine but dislikes the wind. Therefore the shelter, but not the actual shade, of woods, fields surrounded by stone dykes and generally well sheltered, and also bracken patches will be found the worst for strike. It is probably wind, more than low temperature, which keeps the flies off the high hills ; and it was the stillness combined with the warmth of last summer that enabled them to establish themselves on the high pastures.

Conditions Inducing Maggot Fly Attack.—Perhaps the greatest problem presented by the sheep-maggot fly is the nature of the attraction which the fleece has for it under certain conditions. Apart from its connection with sheep, it is a carrion feeder, laying its eggs, like the blue-bottles, on dead animals. It is not attracted by sheep's dung, when dropped normally ; yet it will blow round

the tail of a scouring animal. Research carried out in Australia indicates that it is the bacterial rotting of part of the wool fibres (especially when wetted) in combination with the secretions of the skin which attracts the female flies. This would account for the observed fact that the fly strikes most in showery weather (which wets the fleece) with warm spells and blinks of sunshine (which encourage bacterial activity and odour). The severity of strike in 1933, which was a hot, *dry* summer, was probably due to excessive sweating of the sheep. Nevertheless, the questionnaire replies showed that when showery periods occurred, they were accompanied by increased maggot strike. Heavy dews also can be as deadly as showers. Bracken remains wet long after a shower has stopped, and then passes the moisture on to the sheep as they force their way through it, the shoulders and neck being especially affected.

Once a sheep has been struck, and the maggots have hatched and started feeding, the attraction to flies is greatly increased. The skin becomes inflamed, and later probably broken, and the presence of the maggots induces the formation of a sticky and smelly brown-staining substance, which seems particularly attractive to flies. If a strike is not discovered, or if a maggotted sheep is not properly cleaned, it will be the focus for a larger number of flies, which will blow round the strike area. One such lamb examined near Aberdeen was found to have between 80 and 100 clumps of eggs in its fleece round and about an old strike patch. Many of the sheep farmers who replied to our questionnaire stated that the great trouble in 1933 was *re*strikes, and the consequent impossibility of keeping the sheep clean once they had been struck. We came across some sheep in the neighbourhood of Aberdeen which were struck every other day or so for nearly a fortnight.

The laying of eggs, or oviposition, by the female is by no means a casual process. Observed in the laboratory with captive flies the actual laying took 30 minutes, and was preceded by more than half an hour's "exploration." These females were exceptionally large and well-fed specimens, and laid unusually large egg batches (sometimes containing as many as 250 eggs; and producing a total of nearly 2000 in their lifetime). In the wild state probably under 100 eggs would form a single batch, which would naturally not take so long to lay. Even so, they are apparently laid with great deliberation, for egg clusters have been found actually against the skin of a fully fleeced sheep. To lay these the flies must have forced their way through several inches of wool. A staple of wool with egg batches at the base of the fibres are shown in Fig. 2. Given favourable conditions of temperature and moisture we found that eggs could hatch in under 24 hours; but probably not much under.

Treatment of Affected Sheep.—The question of the practical treatment of maggots in the flocks falls under two heads: preventive dipping, and dressing the affected animals. It is not possible to

say much about dipping. The experience of farmers indicates that in many cases it is effective, in others not so. The majority of the replies which gave specific opinions on the matter stated that 14 days seemed to be the limit of the effectiveness of a preventive dip.

There are two factors which militate against the successful use of dips to-day. The first is that the exact chemical nature of the attraction in the fleece is not understood as yet ; and it is therefore not easy to counteract it. The second is that to be effective *against the maggot fly* a dip must be kept clean, a precaution which is often neglected. Dirt and dung in a dip will counteract its beneficial effect, and might even make the sheep more attractive to flies (as one of the farmers stated semi-jestingly in his reply). It is not generally realised that very little is needed to turn the scales against the sheep, and cause the fly to strike. Dirty dip may do this : so may the use of dip that is over-strong. It raises a scurf from the skin, which rots in the wool. Many farmers' replies emphasised this point. When flies are striking badly it is perhaps natural to think that double-strength dip will be more effective ; but it should not be used. More than one farmer in his reply advocated the use of *half-strength* dip for fly. Sheep whose skin has been cut by maggots should not be put through a poisonous dip. Neither should maggotted sheep. Dead maggots in the wool will sooner or later attract flies.

From the replies received there seems no doubt that a farmer who makes sure that his dip is clean and who realises that when flies are striking badly it will only protect the sheep for a certain length of time (and dips accordingly) can derive very great benefit from dipping. Several farmers stated that they dipped four or five times during 1933.

In the matter of treating affected sheep an experienced and observant shepherd often can, and does, reduce possible serious losses to practically nil. Nine-tenths of the battle is the early recognition of a strike. Once the skin is cut the problem is complicated by the necessity of healing the wound, which in itself is a strong attraction to other flies. The failure to recognise this vital point is the cause of a great proportion of the trouble. Shepherds like to see the dressing they use kill the maggots, and kill them quickly. It is safe to say that almost any dressing which kills the maggots *rapidly* is dangerous to use, especially if the skin is inflamed or cut.

The delicate tissues of a wounded skin cannot be treated with substances at rapid-maggot-killing strength without being irritated ; when the healing process will be slowed down, and pus likely to form—simply inviting a second strike. A shepherd will often carefully clip away a pocket of maggots, and the wool round about : then, after making sure that no maggots are left in the fleece, will pour on and rub in a dressing whose strength has been judged by its power to kill maggots, when there are none left in the fleece to

kill! In dealing with maggotted sheep, the following points should be kept in mind:

(1) It pays again and again to catch the strike early, before the skin has been broken. If this is done almost any dressing can safely be used; and there is no point in making it strong, as long as the spot has been *properly cleaned*, leaving no trace of the brown, smelling matter which the presence of the maggots induces.

(2) Not only should the pocket of maggots be cut away, but the wool for an inch or so round the spot should be clipped short. This often lays bare a discoloured streak (which would otherwise be missed) showing that some of the maggots have wandered to another part of the fleece.

(3) If the skin has been cut or is badly inflamed, *on no account* should poisonous dip be used as a dressing. Arsenic is absorbed into the body through wounds and inflamed skin (several farmers in their replies confessed that they had killed a sheep by dressing maggot wounds with poisonous dip). And do not use the dressing too strong. The maggots should all be cleaned off, and an antiseptic dressing at healing, and not irritating, strength used.

(4) All maggots removed from the fleece should be killed. It is astonishing how rarely shepherds take the trouble to do this, allowing full-sized maggots to crawl away. We tested in the laboratory the power of maggots, which had not voluntarily left their food, to pupate and produce flies. It was discovered that maggots which had enjoyed little more than half the normal feeding period could complete their life history; though they gave rise to under-sized flies.

There is no space here to review the properties, good or otherwise, of the various substances which are in use as dressings. The following summary, however, may prove useful.

An oily dressing penetrates the fleece more easily than a watery one, wool being greasy. The best oils to use as solvents for a dressing are (among others) whale oil or cotton seed oil.

Certain substances commonly employed in dressings, for example, carbolic acid, cause scalding of the skin if used too strong, resulting in a subsequent lifting of the wool (see Figs. 4 and 5). Paraffin, even if diluted with water, will do this.

Carbolic acid makes a very useful dressing, if used at about 4 per cent. strength. It can be dissolved in water or whale oil (in the latter case the crystalline form, phenol, should be used). Carbolic has no definite repellent action on flies; but by cleaning and disinfecting the wound and surrounding wool it removes attractive odours, and thus prevents strike, which comes to pretty well the same thing.

A 5 per cent. solution of copper (or zinc) sulphate in water is antiseptic, rids the struck area of maggots, and being astringent helps to dry and heal the wound. It makes a useful, and cheap, dressing (which, though little used in this country, has been dis-

covered by one or two farmers, as the questionnaire replies showed). The zinc salt is better than the copper as it does not colour the wool.

It is hoped to make tests during the coming season of dressings incorporating one or other of the very few substances known which are definitely repellent to the flies. A limited trial was made in 1933 of a mixture recommended by the South African Department of Agriculture, made up as follows: Cotton seed oil, 45 parts (by volume); petrol, 40 parts; pine tar oil (*Ol. Picis*), 10 parts; carbolic acid, 5 parts. It was an easy and pleasant dressing to use, penetrating the wool rapidly and thoroughly. It appeared, as far as we could tell, to be satisfactory in preventing restrikes; but it may have the drawback of staining the wool.

The following points on the subject of dressings, which appeared in the farmers replies, may be of general interest. In those counties (such as Argyll) where maggots have always been a serious pest, and farmers and shepherds have had long experience in dealing with them, it is customary to "finish off" a cleaned sheep with a mixture of whale oil and sulphur. An oil alone, such as common lubricating oil, is recommended by some. (Experiments carried out in Australia have raised some doubt as to the real efficacy of sulphur dusting after cleaning struck sheep. It is stated to have no actual repellent action; though it is thought that it may give rise, by slow oxidation, to antiseptic compounds which may help to keep the wool clean.) Many farmers who use some of the proprietary fly oils on the market find that they tend to stain the wool, and state that this can be overcome by adding soap or soda when applying. More than one farmer claimed good results after using *no dressing at all*; but merely removing all maggots, and washing the struck area with pure clean water. Others say that the maggot trouble has increased since the habit of washing sheep in burns has been dropped. (There can be no doubt that many of the dressings used aggravate rather than ease the trouble, as they irritate the skin, prevent healing, and lead to restrike.)

Although the maggot pest has affected Scotland for so long that every shepherd, except a few in the higher pastures of the north, has had experience of it, quite a number of men still regard it in the wrong light. They think of the trouble purely as that of maggots in the fleece which need killing. If the pest was considered from the point of view of the *flies*, there would be a much better understanding of the problem. Sheep-maggot flies occur in numbers, in all but a few special localities, at the right time of year. The great majority of them probably never strike a sheep at all; but they are all, so to speak, prepared to do so. As soon as an animal becomes attractive in their eyes, one or more will strike it at once. A dirty tail, a sweat-soaked fleece, *a wounded or inflamed skin*, will provide this attraction. If shepherds would bear this in mind, and, as suggested, think of the matter in terms of the fly, and the attraction the sheep may have for it, much loss

and trouble would be avoided. "Panic" measures, such as the use of undiluted paraffin or virulently strong carbolic (resulting in disfigured and half-naked sheep), and the application of double-strength arsenical dip to an already ailing lamb, would be recognised as accentuators of the trouble.

Distribution of the Sheep-Maggot Fly.—The local distribution of the sheep-maggot fly in Scotland is very puzzling. Its presence and abundance are naturally judged by the incidence of strike among farmers' flocks (in the absence of direct evidence from trapping). *Lucilia sericata*, as is well known, is not so frequently found on high, exposed hillsides as on the low ground. Nevertheless, it is firmly established on hill pastures over most of Scotland; though its activity will vary according to the season. There seem to be very few spots in Scotland where the fly was not known prior to 1933. Shetland is one, and certain high lands in the east of Sutherland, where the County Organiser reports that "old shepherds with many years' experience on these hills did not know it when they saw it first"—in 1933. Another County Organiser, visiting east Ross-shire, also reported meeting a shepherd on the high herdings who had never seen maggots previously. One questionnaire reply from near Tyndrum, on the eastern border of Argyll, stated that prior to 1933 the fly was not known "apart from an old ram struck on the horn."

Unless the conditions of herding on a particular hill farm are known it is not possible to tell at what altitude the sheep are actually struck. Sheep are usually moved up and down the hillsides every day by the shepherd; and as twenty-four hours at least usually pass between the laying of the eggs and the discovery of a strike, the fly may actually be working at a very different altitude from the one at which the strikes are noticed. Altogether the exposed summits are probably pretty free of the fly; though in a still, hot summer, such as 1933, they may find their way to almost any height.

Even on the low ground the distribution of the fly is extraordinarily "patchy." This fact was noticed in our own investigations, and was apparent from the questionnaire replies, and was also reported by the Sutherland County Organiser: "the pest was very bad in certain places, while in others it was practically non-existent; and this could be seen even on the low ground in the case of farms within half-a-mile of each other." Even allowing for the difference between breed and treatment of sheep (dipping, etc.), which would affect the severity of strike, and hence the apparent abundance of flies, it is evident that the distribution of *Lucilia sericata* is dependent on local factors which are not yet understood.

It seems almost certain that the sheep-maggot fly is still advancing and increasing in the north. Several farmers stated that the trouble had been gradually getting worse over the last years. A student in the Department who made careful enquiries in the high country round Dufftown reported that maggots were hardly known

there twenty to thirty years ago—"they were a curiosity." In 1933 a farm (about 800 feet above sea level) lost 20 sheep outright among a flock of 1200 Blackfaces, and had as many as 43 lambs in a batch of 400 struck in one day, and several animals struck as many as half-a-dozen times in the worst part of the season.

Although the pest is now liable to be serious in all low-lying land as far north as Caithness, the southern counties are still relatively worse affected. There extra dipping (sometimes once a fortnight in the worst months, July and August) and the use of a compounded dressing are considered essential at times. Many northern farmers are apparently reluctant to undertake this, stick to the two statutary dippings, and use paraffin as a dressing because it is cheap. The normally greater severity of the pest in the south is indicated by a reply from an Aberdeenshire farmer, who stated that 1933 was the worst year experienced in that district; but that he had known it much worse in Argyll in past years. A Peebles farmer, who owned a farm in Nottinghamshire, wrote as follows (throwing light on the conditions still further south): "In Notts conditions were painful. Many sheep became emaciated with constant herding and penning. Lambs suffered, and could not be got fat, consequently had to sell as stores, losing at least 10s. per head."

Estimates of Losses Involved.—In the questionnaire farmers were asked to give an estimate of their losses due to the maggot pest in 1933, in order to provide some idea of the cost of the fly to the industry. The answers again showed the extraordinarily "patchy" nature of the trouble. Many replied that their losses were inconsiderable, or nil, or often "just a lot of extra work for my shepherd." The two most difficult items to assess in terms of hard cash were clearly the loss in market value of sheep struck, and extra work (where no additional labour was hired). One man was probably voicing the feelings of many when he wrote, "No extra labour was hired; but owing to the continuous time spent with the sheep, other work on the farm was neglected." The following attempts to estimate the losses involved will be of interest. The examples are mostly selected for the care taken to arrive at an estimate, and probably represent cases of farms which were troubled to an unusual degree.

Banff (fairly high)—400 ewes, plus lambs.

Dipped four times. Lost 10 ewes and about 12 lambs. Did not market 20 or so lambs, which were broken in wool. Total round about £40.

Aberdeenshire (high)—1000 ewes, plus lambs.

	£	s.	d.
Lost 5 sheep @ 30s.	£7	10	0
Extra dip	6	10	0
Loss of market value of 600 lambs @ 3s. per head (for disturbance of putting them together every day)	90	0	0
	£104	0	0

Argyll (low)—1400 ewes, plus lambs.

"Approximate estimate £150-170."

Argyll (Ardgour)—900 winter stock.

£63 through deaths alone. Loss of market value and cost of dip £9.

Argyll (Ardgour)—6500 sheep.

"Many of the sheep struck are never seen again. They wander blindly into the sea, streams, or anywhere. A maggot season is a 'black loss' season. Loss I calculate approximately at £300. Possibly this is an underestimate."

(Other Argyll replies stated "cost negligible.")

Mull—900 ewes, plus lambs.

52 ewes @ £2	£104	0	0
6 ewe lambs @ 15s.	4	10	0
10 wether lambs @ 10s.	5	0	0
	£113	10	0

Plus 3 gallons "Maggotine," and a 24 lb. pail of Young's "yellow label" dip.

Islay—2400 sheep.

5 sheep died, say	£7	0	0
12 damaged, loss in value	3	0	0
Dip and dressing	5	0	0
No extra labour hired, but more time taken by shepherd ; therefore loss to other work, say	5	0	0
	£20	0	0

Wigtown (low)—500 ewes, plus lambs.

One ewe died	£1	5	0
4 cross lambs unfit for market	1	0	0
5 B.F. lambs unfit for market	1	0	0
Cost of dip	8	0	0
	£11	5	0

Kirkcudbright (low).

"Not over £5 on 1400 sheep."

Dumfries—400 ewes, plus lambs.

No deaths. No loss in market value. Cost of dip and dressing for 400 ewes and 600 lambs, £19, 15s. 0d.

Ayr.

"I consider every sheep with maggot strike depreciates 5s. to 10s."

Selkirk.

"Any sheep badly affected would lose 50 per cent. of their value."

Roxburgh.

"The indirect loss due to continual penning for treatment and disturbance of flocks is very great, and cannot be less than 2s. per head."

Roxburgh (fairly high)—1200 sheep.

Chief loss due to loss of condition, and failure to market at proper time.

Say, 50 lambs @ 5s. per head . .	£12	10	0
30 ewes @ 5s. per head . . .	7	10	0
Extra dressing	5	0	0
	£25	0	0

(Two other Roxburgh replies in quoting loss of market value of " broken " lambs, estimate this at 10s. per head.)

Berwick—1700 sheep.

$\frac{2}{3}$ shepherd's wages for 4 months .	£21	6	8
$\frac{2}{3}$ cost dips and helpers . . .	14	0	0
150 lambs damaged @ 5s. per head .	37	10	0
50 ewes damaged @ 2s. 6d. per head	6	5	0
Loss of wool (calculated in detail) .	1	3	8
Cost of dressings	2	5	0
	£82	10	4

There can be no doubt, after considering the replies quoted above, and taking into account the numerous farmers who lose from five to ten pounds annually through the pest, that the sheep-maggot fly, all in all, causes a very considerable financial loss to Scottish farming; and it is clear that the problem fully merits the attention of scientists, with a view to discovering more satisfactory methods of control. The Aberdeen University investigation will be continued; and it is hoped that farmers will not hesitate to communicate any information likely to be of interest or value to the Natural History Department, Marischal College. We should like to take this opportunity of thanking the farmers (to the number of nearly 700) who replied to our questionnaire. The information supplied has already been of great value, and will undoubtedly prove particularly useful in the further investigations which are being planned.

THE QUALITY OF PROTEIN IN RELATION TO MILK PRODUCTION

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IT has long been recognised that, in order to secure from dairy cows their maximum yield of milk, it is necessary to include an adequate quantity of protein in the production ration. As a result the employment of protein-rich concentrates, such as linseed cake and earthnut cake, has become an almost universal practice. At the same time numerous feeding trials have been carried out with the object of providing a standard for calculating the protein requirements for growth, maintenance, and milk production. The milk production standard most commonly adopted in this country is that recommended by the Departmental Committee of the Ministry of Agriculture (1), *i.e.* 0·6 lb. protein equivalent per gallon of milk. Such general feeding standards are, however, necessarily based on the assumption that the proteins of the common foodstuffs are of equal nutritive value.

The function of protein in animal nutrition is to provide the body with adequate quantities of available nitrogen. It is, however, essential that part of this nitrogen should be supplied in the form of certain amino-acids which are indispensable constituents of the tissues and secretions, but which the body itself is unable to synthesise. For the ruminant these essential amino-acids are lysine, tryptophane, and arginine and histidine. The efficiency with which a given food protein will meet the requirements of any specific function, such as growth or milk secretion, will obviously depend on the extent to which it is able to supply these essential amino-acids in adequate quantities and in the correct proportions. It is, for instance, apparent from Fig. 1 that certain foods, such as blood meal, pea meal, bean meal, and meat meal, when used as sources of protein for milk production, contain fairly adequate proportions of lysine, whereas earthnut cake, linseed, and flaked maize are markedly deficient in this amino-acid.

Turning now to nutritional studies, it was demonstrated by Thomas in 1908 that proteins derived from different sources might vary in their ability to support growth. In order that such variations might be expressed in quantitative terms, Thomas measured the nutritive efficiency of proteins in terms of "biological values," the "biological value" being defined as the percentage of absorbed (*i.e.* digested) nitrogen which could be utilised for anabolic (*i.e.* building) purposes. Since the publication of Thomas's original work, numerous investigations have been made into the biological values of proteins for growth and maintenance. On the other hand relatively few investigations have been made into the biological values for milk production.

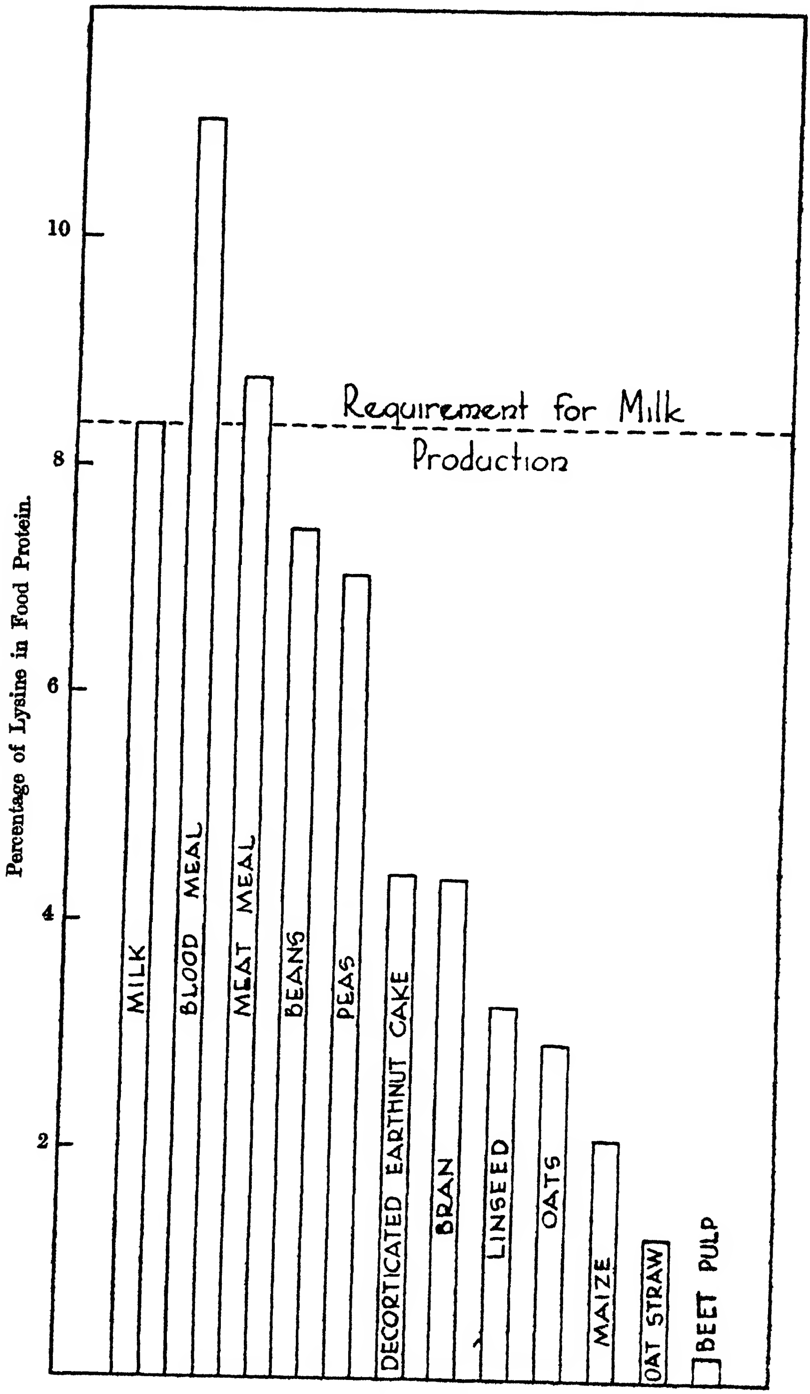

FIG. 1.—Showing the proportions of the essential amino-acid, lysine, in the proteins of common foodstuffs.

The study of the biological values of proteins for milk production possesses, however, one great advantage over similar studies devoted to either maintenance or growth. In the latter the investigator is largely dependent on gross weight changes as a basis for his observations ; in milk production studies, on the other hand, the investigator can base his calculations on a quantitatively accurate figure—the total yield of protein in the milk. On the other hand there are two outstanding difficulties in assessing the biological values for milk production. In the first place the requirements for milk production are always superimposed on those for maintenance. Hence the milk protein secreted does not represent the *total* utilisation of the food protein consumed, since some of the latter is being used to replace normal losses of body tissue. In the second place the level of protein feeding requires careful regulation. If the animal receives too little protein to meet its requirements for milk production, it will tend to draw on its own body reserves to make up the deficiency ; on the other hand, if it receives too much protein, the excess will either be retained in the tissues or will be excreted in the urine, either alternative ultimately leading to erroneous conclusions. The existence of these difficulties has invalidated the results of some workers, while it has deterred others from attempting to establish accurate biological values.

Outline of Experiments.—In the experiments carried out at the Hannah Institute [1] the above difficulties have, so far as possible, been met. Lactating cows were used as experimental subjects, the average daily milk yield at the commencement of the experiments being about 4 gallons. Each animal was fed a basal ration of constant composition sufficient to supply its maintenance requirements. Superimposed on this there was fed a production ration, the protein content of this ration being initially adjusted so that, when an adequate lysine-rich protein was fed, nitrogen wastage was reduced to a minimum. The lysine content was used as a basis of calculation on account of the fact that, with one exception (*i.e.* meat meal), the foods used contained adequate quantities of the remaining essential amino-acids.

The production ration contained the same *quantity* of protein throughout, but the *quality* was varied in successive periods by altering the source of protein. Thus, for example, a period on a ration containing blood meal, a food rich in lysine, was followed by one containing earthnut cake, which is poor in lysine, and this in turn was followed by one containing pea meal, which is again rich in lysine.

Each feeding period was continued until a fairly steady milk yield had been maintained for at least 14 days ; in practice the periods were found to vary from 16 days to 34 days. A complete experiment lasted therefore for from 3 to 4 months.

Method of Measuring the Relative Nutritive Values.—In order

[1] A full description of the experiments will be found in references (2), (3) and (4).

to compare the nutritive values of the different rations it was essential to measure not only the milk yield of the animals, but also the wastage of nitrogenous substances from the body. For this purpose special metabolism stalls were designed in which the liquid excreta (urine) and solid excreta (faeces) could be collected and separated. The stalls, one of which is shown in detail in Plate I, were constructed as follows: The feeding manger was built in such a fashion that the food could not readily be tossed out by the animal. A moveable metal shield at the back of the manger enabled the observer to remove and weigh any unconsumed food. Water was allowed *ad lib.*, but the water-bowls were provided with meters to allow measurement of water consumption. No bedding was allowed, as this would lead to contamination of the excreta. The floor of the stall was therefore constructed of a special asphalt preparation which was durable yet warm. The animal was secured with ordinary adjustable tubular fittings. Behind the animal, in place of the usual "grip," there was a rectangular opening leading to the lower floor. A specially constructed hopper directed all excreta through this opening. The collecting and separating machinery was situated on the lower floor immediately below the opening (see Plate II). Separation of solid from liquid excreta was effected by a slowly-moving, endless belt, driven by a geared electric motor. This belt was carried on rollers, one of which was set somewhat higher than the other, the direction of the belt being on an incline and uphill. The faeces lodged on the belt and were carried uphill, where they were removed by a scraper and fell into a special container. Urine flowed down the belt or over the sides, and was caught in a large funnel which led to a collecting bottle. The apparatus, which was, of course, kept running day and night, effected an almost perfect separation of solid and liquid excreta.

The separate collection of the faeces and urine (and, of course, of the milk) enabled an absolute measure of the utilisation of the food to be obtained. Analysis of the faeces showed the percentage of protein which was digested, analysis of the milk gave the percentage of digested protein which was efficiently utilised, and analysis of the urine provided a measure of the digested protein which was wasted. The combined analyses of the three products, when compared with the total intake of food, determined whether the animal was storing or losing nitrogen. In most experiments, neither storage nor loss occurred, *i.e.* the animal remained in equilibrium.

Results.—The results may be briefly discussed under four heads.

(a) *Comparison of Milk Yields.*—It has already been stated that minimum quantities of protein were fed in the ration, the actual amounts being 0·44 lb. protein equivalent per 10 lb. of milk, as against the Departmental Committee's standard of 0·60 lb. The former quantity would be just sufficient to maintain normal milk yield on a good quality protein, but if the protein were deficient in any essential amino-acid (in the present instance in lysine) a fall in

Plate I.—Upper Floor of Metabolism House.

Plate II.—Lower Floor of Metabolism House.

milk yield would be expected. Fig. 2 shows the lactation curves of two of the experimental animals. The blood meal and pea meal rations contain good quality proteins, the earthnut cake and mixed rations contain lysine-deficient proteins. The broken line represents the normal lactation curve. It will be seen that milk yield is maintained on the good quality protein rations, but that the

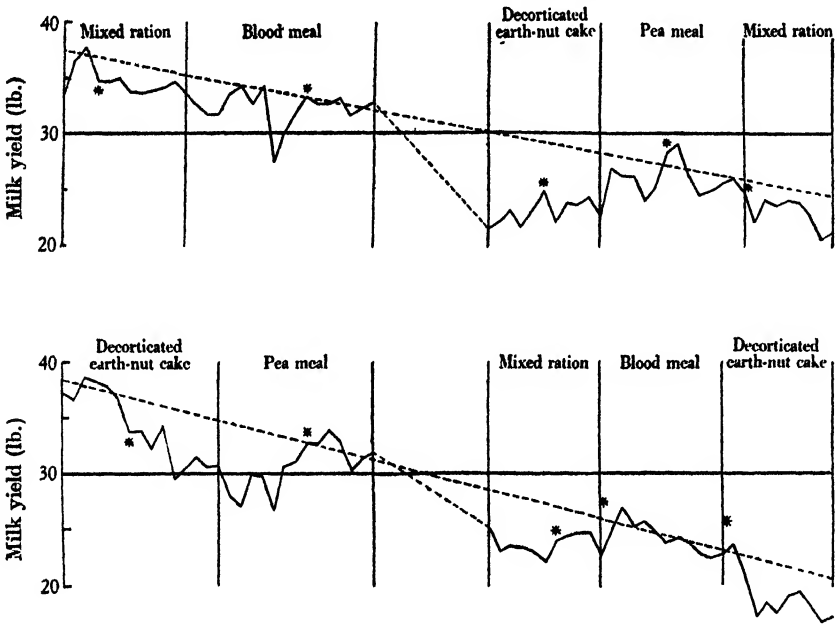

FIG. 2.—Showing variations in milk yield during successive feeding periods.
(*Note.*—Asterisk indicates period used in calculation of biological values.)

feeding of lysine-deficient rations results in a marked fall in milk yield.

(b) *Comparison of Protein Wastage.*—Throughout all feeding periods the same *quantity* of protein was fed in the rations, only the *quality* being varied. If, therefore, the animal is unable to maintain normal milk secretion during the lysine-deficient periods, one would expect to find a high rate of wastage of nitrogenous substances from the body, *i.e.* in the urine. This result is very effectively shown in Fig. 3. The continuous line shows the protein (expressed as nitrogen) secreted in the milk; the broken line shows the nitrogenous waste products found in the urine. It will be seen that high yields of milk protein are accompanied by low wastage; while abnormally low yields, such as occur during the feeding of the lysine-deficient rations, are accompanied by high wastage. Expressed in practical terms this means that on the poor quality rations a considerable part of the protein is simply passed through the body and runs to waste as liquid manure.

(c) *Utilisation of Body Tissues for Milk Production.*—It is a

common observation that the lactating animal will deplete her own body of large quantities of stored food materials, and even of her own body tissues, in order to ensure the nurture of her young. Thus it is very frequently found that milking animals are, during lactation, in negative calcium balance—*i.e.* they are losing more calcium from the body than they receive in the food. In the feeding of poor quality proteins an exactly analogous loss of tissues takes place.

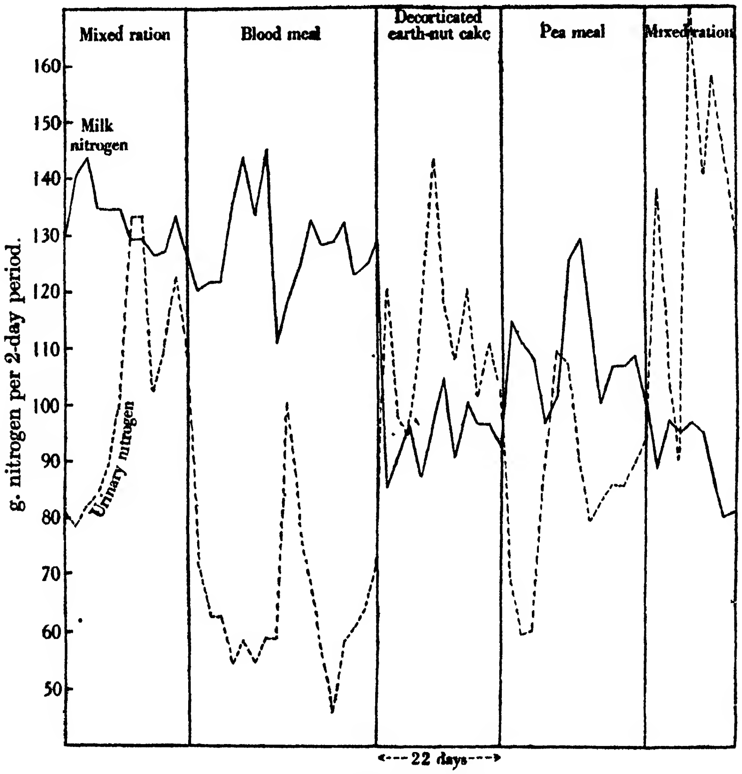

FIG. 3.—Comparison of utilisation (milk nitrogen) and wastage (urinary nitrogen) on different rations.

The appearance of abnormal amounts of certain nitrogenous products in the urine (notably of creatine) is an indication of the breakdown of body tissues. In the experiments carried out at the Institute increase in the creatine content of the urine was invariably found during the feeding of the lysine-deficient proteins.

(d) *Comparison of Biological Values.*—Reference has already been made to the term " biological value " in relation to the quality of food protein. On the basis of the results obtained with six experimental animals (comprising 26 feeding periods) it has been possible to calculate with a fair degree of accuracy the comparative biological values of the proteins of various mixed rations. These values are shown in Table I, where the lysine contents of the rations

TABLE I

Ration containing	(1) Biological Value	(2) Grams Lysine per 10 lb. food intake	Ratio of (1):(2)
Blood meal	73	28	2·6
Pea meal	64	22	2·9
Bean meal	59	23	2·6
Meat meal	55	23	2·4
Decorticated earthnut cake plus flaked maize	52	20	2·6
Decorticated earthnut cake	50	19	2·6
Linseed-oil meal or linseed cake	46	18	2·5

are also listed. It will be seen that biological values of the proteins of the various rations show marked differences, ranging from 46 to 73. Moreover, there is (with one exception, *i.e.* meat meal) a definite relation between the biological value and lysine content, the former being approximately 2·6 times the latter. (The low biological value of the meat meal ration is due to its low tryptophane content. All other rations were adequate in this respect.) It appears therefore that the lysine content of a ration may be considered the " limiting factor " in assessing the nutritive value of proteins for milk production.

Practical Applications of the Experiments.

(a) *Quality of Protein in Relation to Feeding Standards.*—It was stated at the outset of this paper that existing feeding standards have been necessarily based on the assumption that the proteins of the common foodstuffs are of equal biological value. The results recorded above show clearly, however, that their biological values may vary between wide limits. The biological value of a given protein for milk production can be most simply defined as the quantity of milk protein which will be produced from each 100 lb. of digestible protein fed. For example, each 100 lb. of the blood meal ration is capable of producing 73 lb. of milk protein, while each 100 lb. of the linseed cake ration is capable of producing only 46 lb. milk protein. If this is applied to feeding standards for milk production, it indicates that for the blood meal ration the requirement of digestible protein will be 0·41 lb. $\left(i.e.\ 0{\cdot}30\times\frac{100}{73}\right)$ per 10 lb. milk of 3 per cent. protein content, while for the linseed cake ration the requirement will be 0·65 lb. $\left(i.e.\ 0{\cdot}30\times\frac{100}{46}\right)$ digestible protein per 10 lb. milk. *These calculations show clearly that the fixing of definite protein feeding standards is unsound in principle, and that for accurate rationing it is essential to take into account the quality as well as the quantity of the protein fed.*

(b) *The Selection of Rations for Milk Production.*—It is manifestly impracticable to determine the biological values of the proteins of a large selection of mixed rations, and there are technical difficulties which make it impossible to determine the biological value of the proteins of a single foodstuff. Biological values cannot therefore be widely employed in assessing the suitability of a given ration for milk production. It has, however, been noted above that the biological values are directly related to the lysine contents of the various rations, and it appears that the latter may offer a practical basis for calculating requirements for milk production. 10 lb. milk of 3·0 per cent. protein content contain approximately 17 grams of lysine, and *it is obvious that the production ration must contain at least this amount of lysine,* it being assumed that the maintenance ration covers the body requirements for lysine.

For the convenience of those who desire to give effect to this refinement in rationing their milking stock a table has been prepared giving the starch equivalent, protein equivalent and lysine content of a number of typical foodstuffs (Table II). The usefulness of this table may best be illustrated by applying it to two feeding mixtures.

TABLE II

	Starch Equivalent (per 1 lb.)	Protein Equivalent (per 1 lb.)	Lysine (grams per 1 lb.)
Blood meal	0·63	0·750	60·4
Meat meal [1]	0·91	0·650	42·9
Beans	0·66	0·200	12·9
Peas	0·69	0·180	10·8
Decorticated earthnut cake	0·73	0·410	14·1
Wheat bran	0·42	0·100	4·5
Cottonseed meal	0·74	0·350	12·3 [2]
Linseed cake	0·74	0·250	9·6
✓Oats	0·60	0·076	2·2
Flaked maize	0·83	0·086	1·4
Oat straw	0·17	0·009	0·3
Beet pulp	0·65	0·071	0·2
Hay (red clover)	0·35	0·050	2·1 [3]

Production Rations

Food per gallon	Starch Equivalent	Protein Equivalent	Grams Lysine
A. 0·94 lb. beans	0·62	0·19	12·0
2·75 lb. oats	1·65	0·21	6·1
0·75 lb. maize	0·62	0·07	1·0
	2·89	0·47	19·1

[1] Meat meal is deficient in tryptophane.

[2] Lysine content based on American figures.

[3] Approximate value only.

B. 0·50 lb. decorticated earthnut cake . . .	0·37	0·20	7·0
2·75 lb. oats . . .	1·65	0·21	6·1
1·00 lb. maize . . .	0·83	0·09	1·4
	2·85	0·50	14·5
C. 0·88 lb. decorticated earthnut cake	0·64	0·35	12·0
2·75 lb. oats . . .	1·65	0·21	6·1
0·75 lb. maize . . .	0·62	0·07	1·0
	2·91	0·63	19·1

The basis of ration A is bean meal, a footstuff of high lysine content. It will be seen that an adequate quantity of lysine is provided in this ration, which contains less than 0·50 lb. protein equivalent. In ration B bean meal is replaced by decorticated earthnut cake, the protein equivalent having been retained at 0·50 lb. The lysine content of this ration is quite inadequate for milk production. By increasing the quantity of earthnut cake (Ration C) the lysine content has been raised to the requisite level, but the protein equivalent is now unnecessarily high, *i.e.* 0·63 lb. Since the deamination and excretion of this excess protein entail additional metabolic activity, the consequences of which may be detrimental to the animal, the aim of the feeder should be to utilise foodstuffs of high lysine content.

In this connection it is of particular interest to note that foodstuffs which can be readily produced in Great Britain, *i.e.* blood meal, meat meal, beans and peas, have the highest lysine contents and therefore constitute the best sources of protein for milk production.

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OUT-WINTERING OF CATTLE

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THE agriculture of the north-east of Scotland concerns itself primarily with the production of crops for stock consumption and its farmers have acquired a high reputation for efficiency in both crop and animal husbandry. While advances in stock husbandry may not have kept pace with achievements in the field of crop production, it is interesting to note that during the past few years

the farmers themselves, acting in co-operation with officials of the College of Agriculture, have been devoting an increasing amount of attention to possible lines of advancement in the stock industry. On the production side of the cattle industry the following three main lines of investigation have recently been the subject of experiment or of close observation :—

(1) Influence of "housing" on the wintering of store cattle. A comprehensive series of experiments, the largest and most exhaustive hitherto undertaken in this country, has now been completed. The object of these experiments was to ascertain the most economic system of wintering cattle in Aberdeenshire, a county in which the large total of approximately 90,000 cattle of one year and upwards (excluding breeding stocks) are wintered annually.

(2) The economic utilisation of farm foods and concentrates. During the past four years numerous experiments have been conducted by farmers under official guidance to ascertain the value of concentrates as a supplementary winter ration for cattle intended for summer grazing. This enquiry, which was carried out under the Aberdeenshire Agricultural Education Advisory Committee, was designed to assess the value of concentrates as a supplement to turnips and straw from a new angle, that of the live weight gains recorded, not at the time the concentrates were fed, but later when the animals had been pastured. These experiments have provided much useful information.

(3) The Genetic Factor. Concurrent with investigations (1) and (2) an enquiry was carried out with regard to early maturity in beef cattle, the breeding and feeding factors being closely examined. It is clear from this investigation, which is being continued, that a very great improvement can be effected in the commercial cattle of the north-east by raising the standard of breeding and by feeding more liberally and scientifically. It is evident from the economic aspects of the enquiry that with a higher standard of breeding a more intensive system of rationing will require to be adopted and that the need for stockmen with specialised knowledge will become more insistent.

An account of experiments on the out-wintering of cattle carried out by Mr Maitland Mackie, North Ythsie, Tarves, at his farms of Eastertown and Westertown, Fyvie, Aberdeenshire, during the years 1927-30, has already appeared in this *Journal* (Vol. XIII., No. 4). The present article deals with an extension of these experiments which were concluded in the summer of 1933. During their last phase the scope of the experiments was greatly widened and they were placed by Mr Mackie under the supervision of the North of Scotland College of Agriculture.

Systems of Management.—During the years 1931-33 six different systems of wintering store cattle were investigated. In all the systems turnips and straw were the only foodstuffs used, except in

the case of No. 6, where turnips and straw were supplemented with concentrates.

The systems tried, three indoor and three outdoor, were :—

1. Animals tied up in byres.
2. Animals loose and having run of byre and open court.
3. Animals having run of byre with semi-covered court attached.
4. Animals wintered in field with access to shelter shed.
5. Animals wintered in field without shelter.
6. Animals wintered in field with partial shelter (unroofed shed).

All the cattle used in the tests, with the exception of fourteen Ayrshire crosses, were Irish stots approximately six quarter old.

The experiments conducted at Eastertown and Westertown in 1931-32 confirmed the results of earlier trials in two important respects. They showed that Irish store cattle made least satisfactory gains when tied up and that it was possible to secure greater live weight increases in the open with turnips and straw than were obtainable indoors. At this point it was decided to discontinue using tied-up cattle in the experimental tests, as it was considered that the system was economically unsound under the conditions obtaining at Eastertown and Westertown.

Experiments at Eastertown and Westertown, 1932-33.—In the experiments carried out in 1932-33, five systems, Nos. 2 to 6, were tested concurrently and 103 animals were grouped for the purposes of the investigation. As it was considered desirable to have an individual record of all the animals, each one was weighed on the farm steelyard and numbered by means of a metal ribbon inserted through the ear. It may be noted here that the adjacent farms of Eastertown and Westertown are ideally situated for such an investigation. They are 16 miles inland from the sea at an altitude of 400 to 700 feet and extend to 800 acres. Both farms are exposed and provide a rigorous test for out-wintered cattle. During the spring months of 1933 there were two short periods of ten and fourteen days respectively when the weather conditions were very severe. Owing to snow and intense frost it was not possible at these times to feed turnips in the field according to plan, and hay was fed as a substitute.

The 103 animals were grouped as follows :—

Group 1. Byre and Open Court. Fourteen Ayrshire crosses. Cut turnips fed in byre, 82 lb. per head. Straw *ad lib.* Turned out to grass April 20.

Group 2. Byre and Semi-covered Court. Twenty-three Irish Stores. Cut turnips and straw as to Group 1. Put out to grass April 20.

Group 3. Field with Shelter Shed. Twenty-three Irish Stores wintered in 26-acre field of 2-3 years' old grass. Turnips 82 lb. per head given whole on grass. Straw *ad lib.* in shed.

Group 4. Field without Shelter. Twenty-two Irish Stores wintered in 19-acre field of 2-3 years' old grass. Turnips as to Group 3. Straw supplied in heap on field *ad lib.*

Group 5. Field and Partial Shelter (Unroofed Shed). Twenty-three Irish Stores wintered in 16-acre field of 2-3 years' old grass. Turnips 82 lb. per head given whole on field. Straw supplied in shed *ad lib.* Concentrates given during winter months as supplementary ration: 1 lb. cotton seed meal and 3 lb. bruised oats per animal per day.

The average gains made by the respective groups are shown in the accompanying table.

Summary of Results of Eastertown and Westertown Experiments, 1932-33

Group	Average Weight at Start			Average Weight Increase since Previous Weighing									Average Total Live Weight Gain		
	22/12/32			20/4/33			18/5/33			6/7/33					
	cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.
1.	4	3	18	0	2	1	0	0	24	1	2	0	2	0	25
2.	6	3	9	0	3	0	0	0	25	1	1	22	2	1	19
3.	7	1	22	1	0	17	0	1	11	1	1	17	2	3	17
4.	7	2	16	0	3	4	0	3	2	1	0	17	2	2	23
5.	7	0	27	1	0	27	0	1	9	1	1	9	2	3	17

The trials were concluded on 6th July 1933, when forty of the animals were fat and ready for sale. From the point of view of live weight gains these experiments clearly show that the store cattle wintered out of doors did much better than those wintered inside, the food consumpt of turnips being approximately the same in both cases. The "Field and Shelter Shed" system, Group 3, has given the best results in these, as in previous trials, while the indoor systems have produced disappointing results. A striking feature of the experiments is the comparatively small gains made by the in-wintered cattle during the months December to April on a normal ration of turnips and straw and subsequently during the first four weeks after being turned out to grass. From the weights recorded, and also from observations made, it would appear that out-wintering improves the metabolism of the animals and at the same time produces beneficial physiological effects. On a weight basis the evidence of the experiments suggests that the system of "housing" cattle, which is generally practised in the north-east of Scotland, may be scientifically unsound. In the trials under review Irish cattle were used, but it is most likely that similar results would have been obtained with home-bred cattle.

With regard to the out-wintered Group 5, which received concentrates in addition to turnips and straw, the results are perhaps

more of scientific than of practical interest. The ultimate live weight gains recorded by this Group on 6th July did not exceed those of Group 3, which received no concentrates, and it is probable that the nutritive value of the concentrates was largely off-set by the inadequacy of the shelter provided, viz., an unroofed shed. In a shed of this kind the straw would at times become less palatable owing to the effects of rain.

Of the 22 animals comprising Group 4, which were out-wintered without shelter, only 7 registered gains of 1 cwt. or more during the winter period, whereas in Group 3 (Field and Shelter Shed) 17 reached this mark. While it is possible that the animals of Group 4 may have suffered to some extent from the inclemency of the weather, it is more likely they did not benefit fully from the straw supplied which was fed in the open. It is noteworthy that the animals of this Group excelled all the others in the gains made on early grass, and that they were the most forward in condition when the groups were finally weighed.

The live weight gains made during winter on turnips and straw alone by the best indoor Group 2, and the best outdoor Group 3, show that a good deal of variation exists in the increases recorded by individual animals within the respective Groups. The figures vary from a decrease of over $\frac{3}{4}$ths of a cwt. to an increase of $1\frac{1}{2}$ cwt. in Group 2, and increases of from $\frac{1}{4}$th of a cwt. to 2 cwt. in Group 3. The variations are more marked in the case of Group 2, wintered indoors, and would indicate that the system of management was not conducive to a high degree of uniformity in the matter of live weight increase. The variability shown would appear to be largely due to nutritional and hygienic factors. These results emphasise the necessity of having fairly large numbers of cattle in experimental trials of the kind described here, so that the effects of rationing may be interpreted more reliably in relation to whatever system of management is being adopted.

Loss of Weight on Early Grass.—In a number of recent experiments it was noted that when cattle were first turned out to grass after being wintered indoors they invariably lost weight.

Thus in the 1931-32 trials carried out at Westertown, a number of animals which were reweighed a fortnight after being turned out all showed decreases ranging from 60 to 7 lb., the average decrease being 31 lb. It was considered that a good part of this loss of weight was real, and that it was due to the laxative nature of grass as well as to the fact that the animals had a free range for exercise. In the following year's trial it was decided to feed turnips on early grass in the expectation that the cattle would rest more and record improved gains.

Group 4, which had been out-wintered without shelter, was divided into two lots on 20th April 1933. One lot was put into a fresh field of 3-year old grass, and turnips were discontinued; the other lot was kept in the field in which it was wintered and

given 70 lb. of cut swedes per head per day for a four-week period to 18th May. The summarised results are as follows:

11 Animals in each Lot	Average Live Weight Increase Period April 20–May 18 cwt.	qr.	lb.	lb. per day
Lot 1. Turnips on grass .	0	3	17	3·6
,, 2. No turnips on grass .	0	2	16	2·6

The live weight increase made by Lot 1 on early grass with a supplementary ration of turnips, viz., 3·6 lb. per day, is outstanding. At the same time, the gains made by Lot 2 without turnips, viz., 2·6 lb. per day, are high and can be accounted for only on the assumption that as the animals were out-wintered without shelter they were able to make the best use of early grass. The average daily gains made by the out-wintered Groups 3 and 5 during the same period were 1·4 lb. and 1·3 lb. respectively, while in the case of the in-wintered Groups 1 and 2, the average daily gain was slightly less than 1 lb. per head.

From a practical point of view, these results indicate that a profitable outlet can be found for surplus turnips on Aberdeenshire farms during the month of May by feeding them to cattle on early grass. They also indicate that in the transition from winter keep to summer grazing, particularly in the case of housed cattle, a supplementary ration such as cut swedes may prove invaluable in maintaining a steady live weight increase during the initial period of the grazing season.

Effect on Grass of Out-Wintering.—As the belief is widely held that temporary leas are liable to become "poached" as a result of out-wintering, a subsidiary trial was arranged to provide information on this point.

Group 5, which had been out-wintered in a 16-acre field of 2-3-years' old grass, was divided into two lots of 11 and 12 animals. Lot A was put into a fresh field, while Lot B was kept in the field in which it was wintered. The weights recorded for the period 18th May to 6th July gave no indication that the grass had suffered through "poaching." The animals which were not moved made quite as good gains as those transferred to a fresh field, as the following results show:—

	Average Live Weight Increase cwt.	qr.	lb.	lb. per day
Lot A. 11 animals . .	1	1	4	3
,, B. 12 ,, . .	1	1	12	3·17

Economics of Various Systems.—In the opinion of Mr Maitland Mackie and his manager the system of out-wintering Irish cattle in a field with shelter shed is economically superior to any of the other indoor or outdoor methods of management. In arriving at this conclusion they have taken into account such factors as the

relative amounts of labour involved; the live weight increase for food consumed; the time taken to finish off the cattle on grass; the killing qualities of the animals; and the financial returns from the respective systems as well as the broad effects of the reduced output of manure which occurs when a large section of the cattle on a farm is out-wintered.

As regards the general principle of out-wintering, it must be noted that in the present extended series of trials, the cattle used were of rather inferior breeding and that they had always been accustomed to out-door conditions. The possibility therefore exists that with home reared stocks of superior breeding, accustomed to being housed, somewhat different results might have been obtained. This possibility, however, is very remote. In the winter which has just passed, a number of home-bred female calves out of Irish cows mated with an Aberdeen Angus bull were wintered without shelter at Eastertown, and they have made exceptional progress.

Probably the two greatest drawbacks attendant on the out-wintering of store cattle for most farms of the north-east are (1) a dislocation of labour and (2) a loss of farmyard manure. The majority of farms in Aberdeenshire are what are termed one- and two-pair places, where the carting of turnips daily to a section of outdoor cattle would interfere to some extent with the normal routine of farm work. There is some reason to believe that the reduced output of farmyard manure would in the course of time adversely affect the fertility of soils by lowering the humus content. At the same time the fact must not be overlooked that quite a large quantity of manure was "made" on the shelter shed system at Eastertown by out-wintered cattle; whilst in a field with no shelter shed a large quantity of manure was also "made" by inducing the animals to gather nightly in one corner of the field, where they were supplied with straw on which to lie.

Conclusion.—It must be said that the statistical evidence of these experiments does not adequately represent the remarkable progress made by stores when out-wintered, even under rigorous conditions. These trials show unmistakably that the housing system generally practised in Aberdeenshire has drawbacks which were not hitherto fully appreciated and point the way to modifications in the system which may be found economically advantageous. They provide new scientific information which will lead to a more definite conception of the problems affecting stock production and they indicate a field for future experimental work on practical and scientific lines. Thanks are due to Mr Maitland Mackie for having undertaken these large scale experiments and to his manager, Mr W. Cumming, under whose care the tests were all satisfactorily completed without a single casualty occurring among the stock.

GRASS CONSERVATION

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Grass is one of the most easily produced crops on the farm and the one which possibly offers the greatest scope for exploitation. Under ordinary conditions the yield per acre from cultivated pastures may be anything from 5 to 10 tons per annum, and with suitable treatment it may be very greatly increased, even doubled. Unfortunately, growth is not uniform throughout the season. There is a peak of production in the months of June or July, the date varying with the district, and this period is the period of hay-making. By manuring and management, however, considerable advances have been made in recent years in levelling out this unevenness. Growth has been stimulated earlier in spring and later in the autumn, with the result that bigger stocks of cattle and sheep can be carried, and there tends to be a relatively smaller surplus at the normal time of hay-making. Owing to climatic conditions, however, and until plant breeders have evolved new grasses, this peak of production will continue to present a problem which has to be dealt with. Of course, winter food has to be provided, and it is not only the surplus which has to be saved. In either case the problems of conservation are the same. When should the crop be cut ? How can it be saved most efficiently for winter use ?

The crop which weighs the heaviest is not necessarily the most valuable. The most expensive part of the animal ration is the protein portion. Carbohydrate foods like maize, barley, etc., are all generally cheaper than linseed cake, bean meal, etc. The percentage of protein in grass is proportionate to the amount of leaf in relation to stem. The more mature and stemmy the grass becomes the lower is the percentage of protein and the higher the percentage of fibre. Taken all in all, therefore, the most valuable crop is obtained when cutting takes place at the maximum point of leaf-growth, just when seed is beginning to form and the amount of stem to increase. The weight of dry matter will be less than if the crop is left till it is more mature, but the material will be more valuable and the aftermath will be somewhat heavier. Woodman at Cambridge and many other investigators have in recent years clearly demonstrated this, and shown that young leafy grass has a composition similar to that of protein-rich concentrates like bean meal or linseed cake.

Having decided on the stage of growth at which the grass should be cut, the next point is to decide how to conserve it to best advantage.

The alternatives may be considered according to the final product, viz.,- (1) Hay ; (2) Silage ; (3) Dried Grass.

Hay.—Losses by exposure to sun and weather begin whenever a crop is cut, but the losses from young leafy grass are relatively greater than from more mature herbage. It must not be assumed, however, that the farmer has been entirely unaware either of this fact or of the greater value of young grass. But he has tried to put the greater, though less valuable, return in dry matter in mature herbage against the greater losses in making the most valuable young grass into hay. It is his methods of hay-making which have been unsuitable for dealing with the younger and more delicate herbage. The crop is rich in protein and vitamins, which are quickly reduced in amount by exposure to sun and rain, and especially by the actual handling of the tender material which tends to break off the delicate and valuable leaves. In hay-making it is essential, therefore, in order to maintain the best quality, to have the grass dried quickly with the least possible exposure and in such a way that the hay retains the maximum amount of green colour. The colour is an indication of the richness in vitamins. There are many methods in use which aim at attaining this result, and new ones are continually being brought forward.

Speed in drying and stacking has been assisted in recent years by the introduction of the tractor-mower, the motor-car sweep and the stacker. On large farms these machines working in conjunction with others for turning and tedding the hay can, if the whole job is well organised, secure the hay crop at a speed which, in the most favourable weather, cannot possibly be much further improved upon. The weather, however, is often unfavourable after cutting, and in many districts it is found difficult to dispense with the intermediate process of coleing. But, again, the coles must be of such a nature that the material can be placed on them as green as possible with the certainty that drying will begin at once. Tripods to maintain a space inside each cole are often used for this purpose, and an interesting innovation is an iron tripod on which the hay can be built, leaving air vents from the outside to the inside space, thus facilitating drying.

There is not sufficient information to say by which method the best results are obtained. The following figures are available from Germany for comparing the value of meadow hay "dried on the ground" and "dried on frames" with hay "artificially dried without loss."

	Yield	Digestible Crude Protein	Starch Equivalent
Grass artificially dried . .	100	100	100
Hay dried on ground . .	76·4	46·1	45·5
Hay dried on frames . .	88·4	91·4	76·3

Crasemann and Steiner investigating the problem in Switzerland found that losses of starch equivalent in drying hay "on the ground"

were on the average 51 per cent.; in drying in frames 40 per cent. With the most favourable weather conditions (hay dried in three days without rain) losses of starch equivalent in drying on the ground were still 40 per cent., while losses in drying on frames after continued rain were as high as 45 to 52 per cent. It may be concluded from the results of investigations carried out on these lines that losses due to drying hay on the ground are usually underestimated, being seldom less than 50 per cent. of the digestible nutrients, while the advantages of drying on frames are probably over-estimated, the losses being below 30 per cent. only in good weather.

In considering the foregoing figures, which are taken from a publication by Kirsch of the Königsberg Animal Breeding Institute, it has to be kept in mind that the percentage losses depend on when the analysis was done. Losses are most rapid before stacking, but even in the stack they continue, although less quickly. The Institute of Animal Nutrition at Aas in Norway found that the loss of feed units when the grass was dried on the ground or on frames was about 20 per cent. of the original feed units in the grass, 14 to 15 per cent. up to stacking, and 8 to 10 per cent. from stacking to 29 weeks later. They acknowledge that this figure is lower than was found in similar experiments carried out by Weigner in Switzerland, and suggest that the difference was probably due partly to the fact that the hay in their case was cut at a more mature stage than in the experiments by Weigner.

It is clear, therefore, that even under the very best of conditions, losses in converting young leafy grass into hay are comparatively high and that much valuable food is lost thereby.

Silage.— In the process of silage-making the weather, which has the greatest influence in hay-making, is of much less importance. It is said, however, to be advisable not to ensile grass when it is wet and that it is better to allow it to wilt a little (Seekles, Utrecht). Last summer at the Duthie Experimental Farm a pasture of mixed herbage was cut and immediately ensiled—in sunny weather—with excellent results. The moisture content when the crop was put into the silo was 78 per cent. In average summer weather it is possible, therefore, to bring the material to the silo without appreciable loss. In comparing whether hay-making or silage-making is the more economical it now becomes a question, apart from feeding tests of the final products, of determining the labour costs, overhead charges and the losses which take place in the silo. The amounts of the first two items will depend on the methods employed in the making of the silage, but, so far as grass silage is concerned, the simplest methods can be employed. Cutting is not necessary, and any kind of air-tight container holding at least 8 to 10 tons of fresh material will serve the purpose. Moreover, it can usually be built, if necessary, where the grass is cut. It may be taken, therefore, that in silage-making overhead charges are likely to

be less than in hay-making, and labour charges not likely to be more.

The two types of grass silage on which we have definite figures as to losses are pit silage and stack silage. Grass silage is seldom made in larger tower silos. These are more adapted for dealing with bulkier crops where cutting and greater pressure are required.

In stack silage the greatest wastage is on the outside of the stack. By making the stack bigger and wider this wastage is reduced; on the other hand, with the greater pressure the loss through the escape of juices is greater. In an investigation carried out at the Rowett Institute the loss in dry matter in the juices in a 100-ton silo was about 40 lb. per day at the maximum, while on a silo holding 200 tons the loss was as high as 380 lb. per day. Pit silos can be constructed to hold about 10 tons of fresh grass in which the wastage at the sides, if the material is carefully packed, is practically negligible, and from which the leakage of juices cannot be very great. These pit silos may be holes in the ground lined with cement or wood, or they can be constructed in circular form of wood panels which are transportable from place to place. The latter type of silo is half in and half out of the ground, the excavation being used to bank up the part above the ground. A number of these varying in capacity from 2 tons to 20 tons were filled at the Duthie Experimental Farm in 1933. Different crops were used and treated in different ways. Grass made good silage, but stemmier crops, such as mixtures of peas and oats, or beans, tares and oats, made moderate silage if the crop was filled uncut. With cutting, a better silage was obtained, but there was evidently not sufficient pressure even in the largest type of silo for this stemmy type of crop. This year, as a result of previous experience, it is hoped to ensure better consolidation.

The following figures are taken from a publication by Rehbock of the Animal Breeding Institute, Königsberg, and give the losses in silage made from pasture.

	Dry matter	Protein	Starch Equivalent
Silage (cold fermentation) in tower . . .	7·4	4·4	—
Silage (stack process) .	33·9	87·4	48·8

The author does not state whether the materials on which his analyses were made were both all edible. If not, there would likely be a greater proportion of waste in the stack than in the tower. Boyle and Ryan at University College, Cork, report that losses of starch equivalent in a pit silo holding 13 to 14 tons of grass were about 25 per cent.

Success in making silage depends on packing the material firmly enough and treating it so that air is excluded, to ensure that there

is the least possible escape of juices. Addition of sugar to improve the growth of lactic acid bacteria and of acids to reduce the pH have been shown by recent work in this country and on the Continent to be merely safeguards and of doubtful value if proper attention is given to the main considerations mentioned above.

For instance, in 1932 at the Duthie Experimental Stock Farm alternate loads of the silage crop, beans, peas, oats and vetches, were filled into two tower silos. One was treated normally, while acid was added to the other according to the A.I.V. process. The losses in both cases were the same, and the materials were of similar feeding value and palatability when fed to dairy cows. Moreover, the further claims by the inventor of the process that the colour in the milk was richer were not sustained.

It may be concluded that in silage-making the crop is easier to handle than in hay-making, but the losses are liable to be greater through faulty management. On the other hand it is probable that under the best conditions the return in food units is better from silage than from hay. Further research work, however, is necessary to determine the relative values of the materials when fed to the animal.

Dried Grass.—This method of conservation is still in the experimental stage, but the results obtained are satisfactory enough to justify full investigation into the question of producing a plant which could be made available to the farmer at a reasonable cost and which would dry grass quickly and cheaply. Of the value of the dried material there appears to be little doubt. Experiments carried out on the Continent and at Jealott's Hill show that the losses in drying are comparatively small, and feeding tests seem to show that the dried grass has retained many of its original properties.

At Jealott's Hill it was shown that grass treated in a band drier resulted in scarcely any loss of digestibility and nutritive value and that the carotene content of the grass was only slightly reduced. In view of the relationship between carotene and vitamin A it would appear that any addition to the winter ration which would increase the carotene content of the butter would also increase its vitamin A content. It has also been shown that the yellow colour of butterfat is largely due to its carotene content, so that any foods which increase the yellow colour in milk are important both from the nutritive and commercial points of view.

A feeding test with dairy cows showed that the milk yield was well maintained when dried grass was substituted for part of the concentrates. During the winter of 1932-33 an experiment was carried out at the Duthie Experimental Stock Farm to test the value of dried lucerne (English product) as part of the maintenance and production ration of dairy cows. This experiment is referred to here because the composition of the material was almost exactly similar to that of dried grass, a sufficient supply of which was not available at the time. The "alternate" feeding method was

employed with one group of 8 cows. There were 4 periods of 28 days each, during two of which dried lucerne was fed while the other two periods acted as controls. Ten lb. of dried lucerne replaced 15 lb. swedes, 4 lb. (approx.) oat straw and 4 lb. concentrates. A study of the milk yields showed that during the periods when dried lucerne was fed there was a definite stimulus to milk production. The fall in yield was checked and production maintained at an almost steady level during the two experimental periods. In another experiment where 8 lb. of dried lucerne was substituted for 30 lb. of silage, a stimulus to milk production was again obtained, and the figure for the total yellow colour of the butter as read by a Lovibond tintometer was raised from 3·20 to 4·40. In both these experiments English produced dried lucerne gave excellent results as regards milk production, and there was an indication that the yellow colour of the butter was improved. The health and weight of the animals were normal, and when the dried lucerne was mixed with the concentrates it was eaten with relish. In palatability trials with the dried lucerne only the dryness and dustiness of the meal seemed to be distasteful for the first day or so, but afterwards the palatability was of a high order. These tests will be continued with dried grass when a supply is available.

The above results are borne out by work carried out in America at the Vermont Agricultural Experiment Station. The workers there found that dried grass was too bulky to replace all the concentrates in the ration of dairy cows, and that the most satisfactory results were obtained when 10 lb. of dried grass was fed with a reduced amount of concentrates. Substituting dried grass for hay on a basis of equal digestible nutrients resulted in an increased milk and butterfat yield.

Whether hay-making, silage-making or drying is the best process for converting grass into a food for use in winter is still unsolved. It is possible that, according to his conditions, each farmer will have to judge for himself and that all three methods will come into use. There can be no doubt that much remains to be done to determine whether, under average conditions of weather and under the best conditions of management, the cheapest and best product is obtained from hay, from silage or from dried grass when all three are made from the same pasture.

THE EFFECT OF LIME ON PERMANENT PASTURE

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An experiment has been recently carried out to show over a number of years the effects of applications of lime in the form of ground limestone to pasture land which was definitely acid and in need of lime. While the changes in the herbage induced by the

treatments received chief attention, determinations were also made of the altered reactions of the soil.

Originally plots were laid down at eight centres scattered throughout the south-west of Scotland. It was, however, possible to carry the work to completion at only three centres—on the farms of Tullichewan, by Balloch; Ellisland, by Dumfries; and Woodhall, by Annan. At each centre half an acre was marked off and divided into four ⅛th-acre plots. Two plots lying diagonally opposite received no treatment, while a third plot received limestone sufficient to supply two tons carbonate of lime per acre, and the fourth plot received limestone at the "lime requirement" rate—that is, the rate determined chemically, which, of course, was different for each centre.[1] Actually this was for Tullichewan 2 tons, 16 cwt. carbonate of lime, for Ellisland 3 tons, 16 cwt., and for Woodhall 6 tons per acre.

Tullichewan.—At this centre the soil was a medium to heavy loam containing 8·5 per cent. of organic matter, and the field in which the plots were located was occupied by old permanent pasture dominated by bent and Yorkshire fog. Galloway bullocks grazing the surrounding field had free access to the plots.

The first evidence that the lime was beginning to have an effect was seen six months after its application. The limed plots, particularly that receiving the 2 tons, 16 cwt. calcium carbonate per acre, were being a little more closely grazed by the stock. This was evident, though there was no noticeable difference in the botanical composition of the herbage of the various plots. This differential grazing was continued throughout the experiment, and after two years the limed plots were quite distinct from the unlimed. They showed a more vivid green, and the amount of bent was diminishing rapidly. Still the 2 tons, 16 cwt. plot had the advantage. At this time a remarkable number of thistles, occupying from 10 per cent. to 15 per cent. of the area, appeared on the limed plots. Only occasional plants occurred on the untreated plots, while the rest of the field was almost entirely free from them.

After four years the boundaries of the limed plots were clearly demarked by the brighter green colour, the closer grazing and the change in the proportions of the component plants. To measure the changes which had been induced, botanical analyses were made by the "Point Quadrat" method. The analyses of the two control

[1] The Hutchinson and M'Lennan lime requirements on which applications were based are given below together with corresponding pH (water) and Lewis and Hardy lime requirement values at the beginning of the experiment :—

Centre	pH	LR. (H. & M'L.) $CaCO_3$ Per cent.	L.R. (L. & H.) $CaCO_3$ Per cent.
Tullichewan	4·70	0·283	0·315
Ellisland	5·17	0·383	0·495
Woodhall	4·77	0·600	0·626

(untreated) plots have been averaged and placed beside those of the limed plots.

Percentage Botanical Analyses (omitting Thistles) showing Changes induced by Two Rates of Liming after Four Years.

Species	No Lime	2 tons Carb.	2 tons, 16 cwt. Carb.
Bents	51	21	6
Yorkshire Fog	19	15	17
Sweet Vernal	10	4	4
Fine Fescues	5	19	27
Meadow Grass	4	10	15
Crested Dogstail	..	2	3
Cocksfoot	1	2	4
Wild White Clover	5	17	12
Buttercup	5	7	7
Daisy	..	3	3
Selfheal	..	..	2

The changes in the soil are indicated by the figures given in the footnote.[1]

Ellisland.—The soil of the field at Ellisland on which the plots were laid off was very fine, sandy and open textured, containing only 4·5 per cent. of organic matter and a great many stones. The soil itself and the vegetation indicated a very low state of fertility. This field had been lying under so-called permanent pasture for an unknown number of years, the herbage consisting almost exclusively of bent, Yorkshire fog, and sweet vernal. The grazing animals in this case were Blackface sheep.

As at the previous centre the effect of the treatments began to be seen after about six months in the greener and healthier appearance of the grasses. The plot receiving the 2 tons looked slightly more promising than that treated at the rate of 3 tons, 16 cwt. per acre.

At two years from the time of treatment a noticeable difference was taking place. The sheep were tending to graze down the limed plots, particularly that treated at the 2-ton rate, more than the surrounding areas which were rough and tufted with much withered material. Bent and sweet vernal were decreasing in amount and were being replaced mainly by crested dogstail.

During the following two years the changes went on continuously. More and more were the limed plots cropped down closely

[1] Soil Data Two and Four Years After Treatment

After	Treatment	pH.	L.R. (H. & M'L.)	L.R. (L. & H.)
2 years	2 tons	5·78	0·112	0·150
4 ,,	,,	5·99	0·126	0·231
2 ,,	2 tons, 16 cwt.	6·02	0·096	0·191
4 ,,	,, ,,	5·73	0·088	0·292

and dogstail, from being present in very small amounts, became the dominant species. Only on the limed plots did thistles appear.

The botanical analyses at the conclusion of the experiment are given in the following table :—

Percentage Botanical Analyses showing Changes induced by two rates of Liming After Four Years[1]

Species	No Lime	2 tons Carb.	3 tons, 16 cwt. Carb.
Bents	43	8	9
Yorkshire Fog	28	16	25
Sweet Vernal	25	2	8
Crested Dogstail	3	56	41
Wild White Clover	trace	10	6
Daisy	..	trace	..
Hawkweed	..	2	..
Moss	..	3	8
Buttercup	..	..	2
Plantain	..	trace	trace
Selfheal	..	trace	..

Woodhall.—At this centre the soil was a light loam with a fairly high organic matter content—13·8 per cent. The field where the experiment was conducted did not carry old pasture as in the previous cases but was sown down to grass in the same year as the applications of lime were given. The oat nurse crop, with which the grass seeds were sown, yielded considerably more grain from the treated plots than from the controls, the heaviest yield being from that receiving the 6 tons per acre. Oats are usually considered to be little affected by acid conditions, but apparently the degree of acidity encountered here was such as markedly to depress the productivity.

Accurate botanical analyses of the plots were not made, but it became early apparent that the success of the grasses depended on the amount of lime applied. On the plot treated at the heavy rate the number of grasses establishing themselves and their growth was greatest. While on the plot treated at the standard 2-ton rate growth and establishment were better than on the controls, they were not quite so good as where the full lime requirement had been given. In the absence of lime, establishment and subsequent growth of sown species were poor, but weed growth was profuse. Spurry was most prevalent in the early stages. Perennial ryegrass

[1] Soil Data Two and Four Years after Treatment

After	Treatment	pH.	L.R. (H. & M'L.)	L.R. (L. & H.)
2 years	2 tons	5·45	0·244	0·461
4 „	„	5·81	0·108	0·371
2 „	3 tons, 16 cwt.	5·71	0·211	0·360
4 „	„ „	6·16	0·271	0·218

was frequent on all plots, but was much more vigorous in the presence of lime. Cocksfoot was more plentiful on the treated plots than on the controls, where only a few plants were in evidence. Timothy was scarce on both the controls and the plot treated at the 2-ton rate, but was more in evidence where the heavy dressing was given. Crested dogstail appeared in small quantity on both the limed plots but was absent from the controls. Bent, entirely absent from the heavily treated plot, was very scarce on the 2-ton plot, while small amounts were seen on the controls. Yorkshire fog, while fairly common on both the limed plots, was much more abundant on the controls. Annual meadow grass and sourocks were plentiful, but decreased in amount with increased lime. On the other hand, daisies and hawkweed became more prevalent with increasing lime.

Discussion of Results.—At each centre where calcium carbonate was applied to acid soil at a standard rate of 2 tons per acre and at a rate indicated by the Hutchinson and M'Lennan lime requirement test (which was always greater than the standard rate), the amounts of bent were reduced. The reductions were always considerable, though at one centre it was almost the same for both treatments, while at the others it was greatest at the heavier rate.

It is generally accepted that Yorkshire fog is much reduced by liming. In these experiments only a slight reduction was recorded after four years. Casual comparison of treated and untreated plots might have led one to suppose that at least half of the fog had been eliminated, but actual counts revealed that in most cases there were almost as many plants present as before, though these were much lower as a result of the more intense grazing, and their leaves were more intermingled with those of adjacent species.

On the two centres where sweet vernal was prevalent marked diminution was effected by the treatments. At one centre there was an equal reduction from both treatments, and less than half the original number of plants remained. At the other a third remained on the lime requirement plot and only a twelfth on the standard rate plot. These results are in accordance with Rothamsted findings where rather less than half the sweet vernal plants survived. There is also agreement in that, next to bent, this grass is susceptible of the greatest reduction by lime. At Rothamsted only between a fifth and a sixth of the bent plants remained after treatment, while in the present experiment it was found that the averages for the two rates of treatment at two centres were approximately a quarter and a fifth.

Fine fescue and meadow grass at one centre gave remarkably responsive increases to the treatments. At the standard 2-ton rate fescue was approximately four times, and at the full lime requirement rate more than five times as numerous as on the control area. The corresponding figures for meadow grass were $2\frac{1}{2}$ times and $3\frac{3}{4}$ times. This is probably quite normal behaviour

for meadow grass. Indeed, the Rothamsted figures show an increase of rather more than tenfold, but the contribution of the species to the total herbage was small (0·15 per cent. and 1·94 per cent.) in comparison to that in the case under consideration. Fine fescue on the contrary is usually found in greatest amount where acid conditions prevail, and at Rothamsted it was depressed by lime. It should, however, be noted that in this instance, next to bent, fog and vernal, fine fescue was the most prevalent grass in the untreated pasture. Further, its habit of growth is such that severe defoliation does not tend to kill it. If the addition of lime of itself is at least not inimical to this species, the increases can be attributed in large measure to the removal of the aggression of bent and sweet vernal.

Crested dogstail increased in the presence of lime at each of the three centres. At two it could not be detected at all on the untreated areas. It made a definite appearance where lime had been given, but only in small amount. At one centre (Ellisland), though its contribution to the controls was small, it was clearly present and struggling for existence against large amounts of bent, sweet vernal and Yorkshire fog. When the two former were reduced as a result of the liming and the grazing, crested dogstail increased enormously. Whereas it contributed only 3 per cent. to the whole, in the controls it gave 56 per cent. at the standard rate and 41 per cent at the 3 tons, 16 cwt. rate. These amounts were in inverse proportion to those contributed by the bent, sweet vernal and fog, thus :—

	Standard rate. Per cent.	L.R rate. Per cent.
Bent + Vernal + Fog . .	26	42
Crested Dogstail . . .	56	41
Sums . . .	82	83

Cocksfoot was entirely absent from one centre and at the others it was present only in very small amount. It did, however, show a slight tendency to increase with increased applications of lime.

Consistently at one centre (Ellisland) the response of the pasture as a whole and of each of the species was more marked on the plot receiving the standard 2-ton application than on that treated at the lime requirement rate (3 tons, 16 cwt. calcium carbonate per acre). The results from the other two centres detailed, and from centres at which the experiments were not completed, indicated that such behaviour was unusual. Generally, treatment at the heavier rates induced greater responses from the vegetation than treatment at the standard 2-ton rate.

Further, at Ellisland both the type of vegetation and the sandy, weathered, structureless appearance of the soil suggested that a deficiency of plant nutrients as well as the acid reaction contributed

to the infertility. If this were so, it is possible that the smaller amount of lime, being sufficient to lower the acidity somewhat and to supply the necessary calcium for nutritional purposes, gave a better balance of nutrients in the soil.

Acknowledgment.—Originally the plots were laid down as part of a scheme of soil investigation initiated by the late Professor Berry who received a grant from the Department of Agriculture for the purchase of the lime.

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STRAWBERRY CULTURE—II

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Strawberry Diseases.—During the past few years the strawberry has been the subject of a great amount of investigation regarding disease. Stocks have deteriorated very considerably as is evidenced by the fact that an increase in the area under strawberries in Great Britain during the last ten years has been accompanied by a decrease in the total crop.

Red Core Disease (Phytophthora Sp. Alcock)[1] **(Lanarkshire Strawberry Disease).**—*Symptoms in the Field.*—The symptoms in the field vary considerably and differ somewhat according to season and variety. Usually the patches of diseased plants are first noticeable in the lower parts of the field often in a badly-drained section, and the grower usually attributes the occurrence to a burst drain or to a like cause. From this centre infection may spread in a more or less circular form. This is not always the case, however, as the centre of infection may occur at the top of a slope or at the bottom of a hill. The disease may spread either uphill or downhill with great rapidity. Infection may occur across or along the row according to where plant contact is most easily obtained. It has been noticed that the disease spreads more quickly uphill than down, and is often checked by crossroads or by isolation. Where the strawberry rows or beds are allowed to form a complete ground cover the disease sweeps right through them, but where the rows are kept separate the spread is usually along the rows. The symptoms may appear in spring or in autumn.

Spring Appearance.—Plants that have apparently wintered quite satisfactorily and have started into growth in spring may appear quite healthy. In April or in May patches appear in which the

[1] A previous paper on this subject was published in this *Journal*, Vol. XIII., No. 3, p. 247.

plants, instead of developing more foliage, actually appear to shrink in size, and newly-formed leaves have a stunted appearance. This dwindling coincides with what is normally a period of active root development, but in an affected plant such development does not take place and the old roots are not able to supply the plant with sufficient moisture for above ground development. Later, owing to the destruction of the water-carrying mechanism, the plants may collapse entirely. Affected plants seem actually to dwindle, but this appearance is partly accounted for by comparison with the development of the nearby normal plants.

Plants with luxuriant foliage collapse more quickly than weaker-growing varieties, and the wilting is particularly noticeable in such varieties as Royal Sovereign, Oberschlesien and Ruskin, but less in evidence in Lord Overtoun and Scarlet Queen. In the Overtouns the leaves become hard and the plant shrivels. After the middle of June there is a partial revival of growth in the diseased plants which has led growers in some cases to believe that the disease was checked. This hope is too often falsified.

Autumn Infection.—If a prolonged wet period is experienced in late July or August autumn spread is severe and winter killing noticeable. The plants brown prematurely, the leaves lose their turgidity, and the whole bed looks weakly.

The maximum activity of the disease as seen in the field is from May to early June and from September to the middle of October.

Root Systems.—The roots on examination show poor development with comparatively few rootlets and much diseased tissue. The almost complete absence of fibrous rootlets and of root division of any kind is a characteristic of the disease. The difference between healthy and diseased plants is most noticeable on sandy soils where of necessity the amount of fibrous root is greatest. In clay soils, even in healthy plants, the root development is comparatively small and the number of rootlets few, so that partial destruction of the root system is not so noticeable but has the same stunting effect. Disease lesions occur as reddish brown patches, usually at the tips but sometimes higher up. When the outer layer is stripped from the root or a section cut longitudinally, a "red core" is found beneath the diseased patch. (In healthy plants the core is white, and the presence of this red core is an unfailing test of the disease.)

The red core may extend some distance above the external evidence of disease, and within the centre of the root the mycelium of the fungus and resting spores may be found. Owing to partial destruction of the root system following autumn or winter infection the plant is unable to meet the demands of spring growth.

There are several root diseases in which brown or blackish lesions appear on the roots, which may or may not be accompanied by a lack of fibrous roots, but are never associated with the "red core." By lifting the plants carefully without breaking any of the small root tips and examining them, using the fingers or a knife to

strip off the cortex from the root, the grower can form a very good idea as to the presence of this disease in the field or in young runners. The disease is more easily detected in young stock than in old, since a fair part of the root system in old plants is in any case dead. It is worthy of note that the two periods of infection, or perhaps more correctly the two seasons during which the disease appears to make the most headway, coincide with the periods of maximum root formation in strawberry plants.

Even though it is not evident in the runners, disease may show during the first year of growth or it may be delayed until the second year. Diseased stock rarely produces a crop, and if fruits are formed, they are hard and dry owing to lack of moisture. It is not uncommon to find young plants collapsing quickly while on older plants the disease has much less effect. An old plant can maintain itself in comparatively active growth on the reserve of food material contained in the root system, and since the foliage is not so vigorous there is not the same demand for water as in young plants. In a strain of plants the disease appears to have a cumulative effect, increasing in severity with each generation of runners taken, until total failure occurs even in maiden plantations. In lifting runners, much of the root system is left in the soil and disease, which might have shown in the tips, is therefore overlooked; thus healthy looking plants may be infected.

Prevention.—The chief method of distribution of the disease is undoubtedly affected plants. Therefore on no account should runners be bought from land or even from holdings where the disease has been known to be present. Infected land, or land on which a crop has failed recently, should not be replanted. The length of time that the disease can remain in the ground is at least six years.

If the disease is present, the plants on the affected areas should be dug out and burned, and every implement used and the boots of the workers should be thoroughly disinfected before passing to non-infected land. When the disease has spread to any great extent in a field, it is rarely possible to grow strawberries successfully on that field or even on the holding.

Soil treatment with cresylic acid has given a slight measure of control, but re-infection takes place. As a precaution against runner infection it is wise to lift the runners from the bed as early as possible in autumn and heel them in over winter. The heeling-in induces the formation of lateral roots, and the plants, if healthy, are in a much better condition for planting in spring. Infection passes from the old plants to young runners as a rule in September or early in October. Severe pruning back of the roots of runners before planting is another measure of prevention.

The production of immune varieties seems to offer the only hope of controlling the disease.

Tarsonemid Mite.—(*Tarsonemus Fragariæ Zimm*).—This mite is

widely distributed in Great Britain, and has been found in several plantations in the Lothians and in Lanarkshire.

In Lanarkshire it is not widely distributed, and owing to the relatively high rainfall and generally cold conditions it possibly does not cause so much damage there as in other areas. (The mite does not like bright sunshine, but on the other hand breeds very rapidly under warm conditions.)

It has not been conclusively demonstrated that the mite is solely responsible for the whole of the damage associated with an attack. Strawberry plants are subject to several kinds of insect and animal injury, the symptoms of which are somewhat similar to those of mite attack. The mite has been found associated with what are termed degeneration diseases, but how far the attack of the mite is linked up with the spread of such diseases has not yet been determined.

A diagnosis of mite attack is difficult, the only definite indication being the presence of the mites themselves. Massee gives the following description : " Affected plants are less vigorous and the leaves are of a dull silvery-green colour, which is later intensified. There is considerable distortion of the leaves, and the leaf petioles are weakened. The young leaves are weak, deformed, and brown in colour. The older leaves are of an olive-green shade with edges of a sickly yellow green. They are turned upwards and are brittle to the touch. In many cases infection of the developing leaves may cause them to become a silvery-brown colour and to remain dwarf."

Runners.—All the developing leaves in affected runners show the typical crinkled appearance ; the texture becomes brittle and the plants are dwarfed and stunted. The leaves are damaged before they unfold, very few mites being found on matured leaves.

The mites seek shelter from sunlight in unfolded leaves where they multiply rapidly. As a result attacked runners are weak and difficult to establish. Infection of the runners occurs as soon as they are formed, and by the time they have rooted the mites have usually started to breed.

Breeding Season.—The Tarsonemus commences to breed during the spring and continues to do so during the summer and autumn months. Hot sunny weather is favourable to rapid reproduction. In Scotland the egg-laying period commences in May and continues during the summer months and may be prolonged until October. Several generations of mites occur during the year, and eggs, various nymphal stages, and adult mites may be found on the same leaf in the summer months.

Eggs.—The eggs are white, transparent, and oval. They are visible to the naked eye and are found in the folds and on open leaflets, usually along the mid-rib of the leaves, but, if infection is severe, may be present also on other parts of the plant. The immature adults prefer cover and are found chiefly in unfolded leaves. The

mites attack the upper surface of the leaves, piercing the epidermis and feeding on the tissue below the surface, but the punctures are not noticeable. Hibernation takes place on the plants in the adult female stage only. Migration is comparatively slow from plant to plant, unless there is close contact between them, but spread from the mother plant to the daughter plant takes place very quickly. The mites spread along the row in patches, and it is significant that the plants which have become isolated in the row, owing to the death of plants on either side, are the last to become infested.

Control Measures.—The best results have been obtained by giving two applications of a spray consisting of a three per cent. solution of lime-sulphur applied by means of a Vermorel " Cascade " sprayer at a pressure of 250 lb. to the square inch, or by the use of petroleum emulsion. It is an advantage to use some form of spreader with these materials, such as Lethylate or Agral.

Recently a method of plant treatment has been introduced which has given considerable success in preventing the spread of the pest by means of runners.

In this method the runners are treated in warm water at a constant temperature of 110° F. for a period of twenty minutes.

" In practice this treatment can be carried out commercially in the field. In Kent, a number of commercial growers have treated their plants successfully by means of a galvanised tank, which is placed on the soil, leaving sufficient space beneath for the fire, and building a chimney at one end. A suitable site for the tank is on the side of a hill or bank. The fire should run the whole length of the tank, as in the method adopted by hop growers for steeping hop poles in a creosote tank. It should also be remembered that the larger the tank the more easily is a constant temperature maintained."

" The water in the tank should be heated to a temperature of 112° F. This is two degrees above the required temperature, but as soon as the runners are placed in the water the temperature drops about three degrees—to 109° F. The temperature should be raised again as soon as possible by stoking the fire under the tank. In practice it has been found convenient to place the runners in cauliflower nets for convenience in handling.

" *It should be emphasised that the temperature must not be allowed to reach* 115° *F. or the plants will be killed completely. On the other hand the temperature must not fall below* 108° *F. or the mites will not be destroyed.*

" The runners should be kept in the tank for a period of twenty minutes, and then removed as quickly as possible. On removal they should be dipped in cold water or spread out to cool off. If the runners are tied up in bundles the bundles should be cut directly after treatment, or they are bound to overheat. Directly the runners have been cooled off after treatment they are ready for planting. There is evidence to show that the plants can be treated at any time of the year without any injurious effect."

"Special apparatus controlled by means of a thermometer is available on the market, but the tank method described above is efficient, provided a good thermometer is used, in order to ensure that the correct water temperature is maintained. The grower who is going to treat runners for the first time would be well advised to have a trial trip, using turnip tops or other greenstuff in order to determine whether the desired temperature can be maintained." (Massee.)

A considerable number of growers have tried the hot-water immersion treatment, but the results are conflicting, possibly owing to the difficulty in obtaining and maintaining the correct temperature. Some reports received on this treatment indicate failures to control the mite or heavy mortality among the plants; these results are almost certainly due to the temperature of the water having been too low and too high respectively.

Recently it has been suggested that the Tarsonemus Mite may have an important bearing on the spread of Yellow-edge, a virus disease of strawberries.

Yellow Edge.—To this virus disease is attributed a considerable amount of the degeneration which has taken place in strawberry plantations during the last few years. The disease has become fairly well established in Scotland, and most infections can be traced to the importation of infected material from England.

Symptoms.—Unfortunately the leaf symptoms which are characteristic of this trouble can be observed only during the very limited period from 1st September to the end of October. In many cases, and in some years, the characteristic appearance is not in evidence before the third week in September. This does not mean that the disease is not present before that time, but the characteristic appearance is not sufficiently marked to decide definitely that the plants are affected by Yellow Edge. It may therefore happen that, where autumn planting is practised, affected runners have been planted-out before the symptoms were showing. The general effect on the plant is to produce dwarf leaves with few runners. The leaflets show marginal decoloration which appears as a yellowish or whitish band round the leaflets. The leaf is dwarfed and often curiously twisted with curving of the mid-rib.

The leaf is not symmetrical, certain of the leaflets being reduced in size. The whole leaf lacks colour—has no speckled parts except at the margins, and the leaf stalk is much shortened and thickened. Symptoms of attack are most noticeable in varieties such as Royal Sovereign and Scarlet Queen. In the latter variety leaf distortion is not so pronounced, but marginal chlorosis is more marked. In other varieties the distinct Yellow Edge is not so noticeable, but the affected plants are stunted and lacking in vigour and the leaves are distorted. Autumn coloration develops at the edges more quickly in affected plants. To some extent premature autumn decoloration also takes place in the case of Red Core Disease, but

the two diseases may be differentiated by an examination of the root system. Infection passes from the mother plant to the young runners, few of which ever escape infection. A mother plant with runners may all show infection, while the neighbouring plants and progeny may be quite healthy. The disease is transmissible by insects, and may be linked up with trouble that previously had been attributed to insect or mite attack.

Control.—The elimination from the plantation of affected parents and runners should be the first step. Every new plantation should be carefully rogued to remove suspicious plants and runners as early as possible so that contact does not take place. It would be advisable for growers to establish runner beds and to control all insect pests.

BURNT OR CARAMEL FLAVOUR IN MILK AND ITS PRODUCTS

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A burnt or caramel flavour in milk and its products is a defect of some economic importance to the dairy industry. Market milk which develops a burnt flavour is practically unsaleable. Butter made from raw cream which is similarly affected is objected to by the consumer and is suitable only for cooking purposes. A burnt flavour in cheese curds is not infrequently noted, especially in warm summer weather, and, while according to our observations it disappears from the cheese during the curing process, the quality of the ripe cheese is seriously impaired.

Macdonnell (1899), Sadler (1911), and Hammer (1921) found that this very characteristic flavour was caused by a lactic acid organism which in its essential characteristics closely resembles *Streptococcus lactis* (Lister), the agent which is the common cause of milk turning sour. Hammer, who named the burnt flavour producing organism *Str. lacticus var. maltigenum*, states that it is of wide distribution and may be isolated not only from affected milk and cream but also on occasion from cow's fæces and from farm water used for cooling milk. In 1918 Leitch isolated from a commercial starter and from a sample of naturally fermented goat's milk organisms of the Streptococcus lactis type which imparted a burnt flavour to cheese milk and to cream used for butter-making. The burnt flavour was appreciable both to smell and taste. The lactic acid organism isolated from the commercial starter lost the property of imparting this burnt flavour after daily propagation in milk for ten days, while the goat's milk organism retained it for nearly four weeks.

Hitherto it has been assumed that organisms causing this burnt flavour are of external origin, and have reached to the milk through

fæcal contamination or have been derived from infected utensils. Stagnant water in pasture fields to which cows have access has also been blamed for the appearance of this objectionable taste in milk. Our investigations have made it clear, however, that organisms responsible for the burnt flavour in milk are frequently of internal origin and are present in the milk before it leaves the udder.

Two years ago a strong disagreeable burnt smell was observed in the cheese curds made at the Experiment Station from the milk of a Grade A (T.T) herd. The fault persisted for a considerable time, and varied in intensity from day to day. As the milk was produced under good hygienic conditions, and a normal pure culture starter was used, the source of the infection was not readily apparent. The milkers were skilled operatives, clean in person, and wore white milking suits. The cows were kept in first-class condition; the udders and teats were washed before milking and the fore-milk rejected. Though the utensils were seemingly clean, the possibility of infection from this source was not disregarded. Just before they were used, the milking pails, the weigh can, and the milk churns in which the milk was conveyed to the experimental dairy were irrigated with sterile water, and portions of the rinsings from each utensil inoculated into sterile milk. If the bacteria causing the burnt flavour had been derived from the utensils the inoculated milk after incubation should have betrayed the characteristic burnt flavour. The results were entirely negative. Direct plating of the rinsings on whey agar also failed to show the growth of any organism which on inoculation into sterile milk would reproduce the defect. These findings were not surprising in view of the fact that the utensils were effectively washed each day and steam-sterilised after this preliminary cleaning. The possibility of a gross infection from external sources such as caused the marked development of this burnt flavour in the cheese-milk might therefore be regarded as small. These negative results suggested that the milk before it left the udder might harbour the causal organisms. Samples of milk were therefore withdrawn directly into sterile bottles from the individual cows after the udders had been specially cleaned and disinfected and after the fore-milk had been discarded. No burnt smell could be detected in the freshly drawn samples, but after these had been incubated at blood-heat for 18 hours, 19 developed a strong burnt smell, 8 a faint burnt odour, while 18 did not betray the taint at all. The infection was clearly intramammary, and no hygienic measures, however perfect, could overcome the defect. It was observed that the milk of some cows in the herd which showed evidence of a definite mastitis infection did not develop the burnt flavour. It was also shown that if the freshly drawn milk were pasteurised to 142° F. for 30 minutes no burnt flavour subsequently emerged either in the ripening milk or in the cheese-curds.

In cheese made from infected raw milk the offending odour is first apparent when the cream layer, which forms on the evening's milk overnight, is broken. The addition of the fresh morning's milk diminishes at first the burnt taste, but after the addition of the rennet, and especially during the cooking of the curd, the burnt odour develops in an enhanced degree. It is strong when the whey is drawn, and is intense at milling. It persists for a time during the initial stages of curing, but eventually disappears in the ripe cheese. The presence of the burnt milk organism in the primary milk causes the cheese to work somewhat fast during the manufacturing process, and to result in a short brittle texture and a slightly bitter flavour in the mature product.

During the past eighteen months we have investigated several outbreaks of a burnt flavour in raw milk, the incidence of which caused considerable trouble to the primary producers and resulted in a temporary loss of their market. In each of these cases the infective organisms were found to be present in the milk of certain cows in the individual herds, and not to be derived from external sources. It will be understood, of course, that, if the milk utensils such as the cooler and transporting cans are imperfectly cleaned, they will become infected, but the primary source of infection is the milk itself.

A producer retailer recently received complaints from some of his customers that the milk sold by him exhibited a disagreeable flavour a few hours after delivery. A sample of such returned milk was found to have a strong caramel taste and an odour suggestive of the smell of treacle. Microscopic examination showed the predominating presence of large cocci in the milk. A portion of the infected milk inoculated into a bottle of sterile milk and also into a sample of high-grade raw milk reproduced the same characteristic odour and flavour after 12 hours' incubation. An examination of the milk utensils, of the water supply in the fields in which the cows were grazing, and of the transport cans, failed to reveal the presence of the causal organism. But when reference was made to the aseptically-drawn milk of the individual cows of the herd, it was found that of the 37 cows in milk 7 had a pronounced intra-mammary infection of the burnt milk organism and 4 were lightly affected. Repeat samples showed that the development of the burnt flavour fluctuated considerably, being more prominent some days than others in the milk of the same affected cows. From the fresh milk of these cows were isolated pure cultures of a lactic acid organism which could cause the typical flavour defect in normal raw milk, in pasteurised milk and in cheese milk.

Nature of Causal Organism.—The causal organism in all these cases was a lactic acid coccus which grows vigorously in milk at room temperature (60-70° F.) and rapidly in milk kept at blood heat. It occurs singly, in pairs, and sometimes in short chains. Apart from the fact that the coccus is somewhat larger in size than

the ordinary lactic acid organism commonly found in milk, it has not, so far as we have been able to determine, any morphological or cultural characteristics by which it may be differentiated from *Streptococcus lactis* except that it has the peculiar faculty of imparting a burnt flavour to milk and whey.

After repeated cultivation in sterile milk the organism loses its ability to produce the characteristic burnt flavour, though it may retain its power of souring milk. Generally we have failed to observe any burnt flavour after daily sub-inoculation for a period of three months or less. Once the faculty of producing the typical flavour is lost it is not re-acquired, even after 18 months' systematic inoculation.

Control Measures.—If the infective organisms, as occasionally happens, are derived from external sources, rigid hygienic measures will eliminate them from the milk. Daily grooming of the cows, the washing of the flanks and udder with water containing a mild disinfectant such as hypochlorite, the rejection of the first five streams from each teat, the use of sterilised milk utensils, and effective cooling of the milk will ensure the rapid disappearance of the trouble. But if the infection is of an intra-mammary type the only effective procedure is to recognise the cows whose milk harbours the offending bacteria. This the producer may do himself by withdrawing a portion of the mid-milk from each quarter of the cleaned udders of individual cows into milk bottles which have been washed in soapy water and effectively scalded. These bottles, numbered to correspond with the cows in the herd, should be kept in a warm atmosphere for 18 to 24 hours and then examined by smell and taste. The cows whose milk is responsible for the fault can thus be determined, and the faulty milk withheld from the market supply. Such cows may remain infective for several months at a time. Even after the trouble apparently disappears from their milk some cows retain a latent infection which is liable to become active suddenly. Rapid and effective cooling of the newly-drawn milk of affected cows will delay the appearance of the burnt flavour, and will prolong its market life. Milking such cows at least three times daily, and stripping the cows very clean will tend to keep the trouble under control, and may eventually lead to its disappearance. As already indicated, pasteurisation of the fresh milk will destroy the offending bacteria, and thereby prevent the emergence of the burnt flavour, but pasteurisation should be performed before the caramel flavour has developed in the infected milk.

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HISTORY OF THE BRACKEN DISEASE

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Of late years the spread of bracken, particularly in the West of Scotland, has reached such dimensions that it has become a serious menace to hill farming. Often the land which suffers most severely is of such low value that expensive methods of control are prohibitive. Considerable interest was therefore aroused a few years ago, when various newspapers noted the presence of a disease in bracken. At the time little was known about any disease of possible economic value on bracken—which hitherto has proved to be a remarkably healthy plant—and much that was then published did not assist the scientific worker. To correct this and in order to supply an authentic statement, a first preliminary paper was published by Mrs N. L. Alcock and the present writer in the autumn of 1928. Since that date a considerable amount of work has been accomplished and a great number of enquiries have been received from different parts of the world regarding the results to date. It is apparent that the cases which have been reported during the last few years fall into one or other of several groups. The aim of the present paper is therefore to give in some detail a review of the investigations which have come under the author's notice during the past seven years. This is especially important as another epidemic may occur at any time. Except where necessary to make the story complete, details given by Alcock and Braid in "The Control of Bracken" (1) or by Gregor in "The Possible Utilisation of Disease as a Factor in Bracken Control" (5) will not be repeated. For clarity, reference will be made to illustrations which appeared in these papers. Subsequent papers will deal with one or other of the disease groups as occasion arises.

Historical.—That the disease is not of such recent origin as was at first supposed is now apparent, as there is a specimen of bracken from Rowardennan, Loch Lomondside, in the Kew Herbarium, labelled *Pteris aquilinum dispar* (1865). It is a typical diseased frond.

In July 1926 Messrs M'Gill & Smith, Ayr, forwarded a sample of bracken which they suspected of being diseased to the Department (then Board) of Agriculture for Scotland. The samples had been collected at Knoweside, Maybole, by the farmer, Mr Allan E. Duncan, who had discovered the abnormal development. It was examined and reported on by Mrs N. L. Alcock, pathologist to the Department of Agriculture for Scotland.

Knowing that the present author was working upon a "hook-disease" on bracken in Dumbartonshire, Mrs Alcock got into communication with him, and all subsequent pathological work has been done in close co-operation. The Knoweside material contained

a number of examples of "hook-disease," but mostly specimens with other symptoms suggestive of a decline disease. At that time no fructifications of any fungus were obtained, though the diseased material in the hook was distinctly infected with bacteria. Ultimately Mrs Alcock isolated a fungus from the Knoweside material, but it was too late in the season to obtain conclusive evidence of its power to re-infect bracken and it did not retain any such power over the winter.

In 1927 a detailed examination was made of the Knoweside area as the disease showed itself. As experience has since shown that this type is by no means uncommon, I shall describe the appearance in detail.

The site, about an acre in extent, was about the highest available —800 feet—and on the whole well sheltered from winds, much of the diseased material lying in rather a shallow, twisting valley. In the bottom part the most luxuriant bracken grew associated with rushes, but the sides of the valley, where most of the dying bracken grew, possessed such a close turf of fescue and bent that the underlying soil was bone dry. The soil was of good depth. and the rhizomes were in two to three tiers to a depth of 20 inches. The fronds were only about 18 inches high, small and relatively sparse, but up to 1925 the bracken had been much taller and denser. Prior to that a slower decline in vigour had been noticed.

In this area there were now three types of unhealthy material. (1) A disease of the "hook" or initial uncurling frond; (2) a decline disease of varying intensity without superficial fungoid pustules on the lesions, and (3) a disease where fungus pustules were discernible and which we later called the Garelochhead type of disease.

1. **"Hook-disease."**—This was confined to the 3 to 6-inch "hook" which was soft and semi-rotten, of a dark brown or black colour and full of bacterial growth. At first sight frost seemed to be precluded as dead black hooks were found beneath already unfolded healthy fronds. Experiments have shown since, however, that the hook in such cases was really killed before the succeeding frond had appeared above the soil, for they exist with little change for several days. I shall hereafter refer to such dead, blackened hook-stage fronds as "frosted hooks." In some years they are very abundant (*e.g.*, 1926 and 1928) and in other years they are almost unknown (1931). As some of these exhibited a horizontal bottom edge to the blackening and others an obliquely vertical margin, it was considered at one time that the latter formed a connecting link between the two types, but I now consider it clear that this semi-vertical margin is due to local shelter afforded by surrounding herbage.

2. **Knoweside Type of Disease.**—The second type of infected material—typical "Knoweside" form—is more difficult to describe. It is characterised by lack of vigour and by abnormal appearances

of the frond. It is often suggestive of early autumnal effects, but the browning is not uniform and does not begin at the tips of the pinnæ, being quite irregular and patchy in distribution. The discoloured areas are dry and firm, never soft and semi-rotten. The fronds are often dwarfed and frequently appear almost "wizened," usually with brownish or black lozenge-shaped markings on the "stems," branches and leaflets. While obviously deformed fronds showed black or brown spots or lozenge-shaped scars on the stems, these blemishes were also visible on otherwise apparently healthy fronds. They run parallel to the long axis and are due either to injury from hard materials in the herbage as the frond pushes its way through or to secondary infection of these lesions. At times the fronds are malformed showing (*a*) the lowermost lateral branches more or less withered and frequently more so on one side than the other, (*b*) the tip of the frond or some of its branches failing to uncurl. This type is characterised by the dwarfed yellowish and sickly-looking, or dry and discoloured fronds, where no apparent traces of fungus attack are present—a "decline disease."

Associated with the disease we have always found some specimens showing pustules on (*a*) the stem-blemishes, and (*b*) the brown tips of the pinnæ or leaflets. In these cases the frond generally possesses a more pronounced lop-sided appearance although it is seldom dwarfed. This I consider to be the "Garelochhead" type of the disease referred to below.

A most interesting point was the general type of grass in which the declining bracken grew. An extraordinarily close turf of fine-leaved fiorin and sheeps fescue, with traces of remains of heather, now excluded the surface water. The snuff-like soil below a compact fiorin-fescue turf reminded me of similar areas near Edinburgh in the College farm of Boghall shown to me by the late Dr W. G. Smith.

As the problem seemed to be primarily an ecological one, the late Dr W. G. Smith was invited to assist with his experience. After a careful survey, we estimated that over the whole hillside there were 12 to 20 per cent. of diseased fronds, but that in the area under examination 90 per cent. of the mature fronds were definitely sickly, the majority of the "Knoweside type." Except where frosted in the "hook," the young fronds appeared to be healthy. The parts above ground were free from insect damage, but some of the underground parts of the fronds were punctured by small holes possibly due to the action of wire-worms. These were often superficial and did not penetrate the sclerenchymatous sheath. The late Mr J. Armour, B.Sc., showed that small holes were produced in many localities also by larvæ of a fly—*Chirosia sp.*

We were informed that the sheep had taken a fancy to the place since the bracken had begun to thin out, and our conclusions were that exposure to winds and sheep above ground accompanied with

lack of water below largely accounted for the continued diminution in growth and healthiness of the bracken.

Before leaving this type there are some general observations that should be made. One must bear in mind the presence of insect attacks and in certain places many of the fronds bear traces of having been attacked. But, while many of these wither prematurely, it has to be realised that most diseased fronds show no signs of insect damage. Mr Angus M'Kechnie (8), Degnish, Kilbrandon, has made out a strong case against the wire-worm, although my own interpretation (after examination at Degnish, through the courtesy of Mr M'Kechnie, and elsewhere) is that the borings of wire-worms are especially abundant on diseased bracken because they are short of other food, the grass having been largely suppressed. Moreover, it is the older insects that we find making the holes, though undoubtedly wire-worms are sometimes locally abundant.

3. **Garelochhead Type of the Disease.**—Mention has been made elsewhere (1) of the largest and most impressive area of this type at Auchaleffen, Kilmore, Arran, where tall bracken of approximately four acres were in most cases fatally attacked in 1928. Inaccessibility to the spot made a detailed study impossible. This also ruled out Mr Dunkeld's interesting area near Dalbeattie, but we have benefited by his observations. Of the severe attacks the Garelochhead area was the next largest to the Arran example and was probably a younger attack than the Dalbeattie one. As it was in convenient touch by rail or road with Glasgow and Mr Hamilton was keen to co-operate, it was made our chief area of study.

The Garelochhead type of bracken disease is divisible into two sub-types; (*a*) the virulent form and (*b*) the non-virulent form. At Garelochhead they are found adjacent to each other and investigations have been made to establish their relationship. In the absence of the history regarding the course of infection, the non-virulent form, unassociated with the virulent form, is often indistinguishable from the "Knoweside Type."

(*a*) The original area attacked at Greenfields, Garelochhead, is about 800 feet above the sea and faces south-west. Until shortly before 1928, it had been one of the most healthy bracken patches on the hill and troublesome to Mr Hamilton as the place of concealment of sheep which had been "struck by the maggot." Early in August 1928 when I first visited the spot, more than half an acre was tangled and rotten, producing a smell suggestive of a bad attack of potato blight. The leafy portions of the fronds soon disintegrated, but the stems stood up, destitute of foliage, bare and dark coloured. Young fronds were quickly infected even before they uncurled. Other patches in the vicinity looked sickly, being lop-sided and discoloured in part. Where the pinnæ or leaflets had not disappeared, the symptoms were (*a*) a marked browning of the pinnæ and often their complete disappearance by withering, (*b*) brown or black lozenge-shaped dots appeared on the stems which

were still of a normal green, and (c) often on these brown spots or on browned pinnæ, definite pustules just visible with a hand lens. The microscope subsequently showed that different kinds of spores were contained within these lesions (2). None of them gave satisfactory artificial inoculations however.

In milder cases the attack suggested early autumnal effects or as one correspondent put it: "The appearance was that of frost, but the patches were such that it would seem incredible that frost would strike in such a sporadic manner."

The first wave of the attack was succeeded by a crop of fresh bracken fronds about a foot high and as they fell victims to the disease a third crop only a few inches in height appeared—the fern had called on its 1929 buds and possibly even some of those destined for 1930. According to Klein (7), the buds which will ultimately produce the fronds are normally initiated some years in advance. W. G. Smith (10) showed that fronds do not all unfold at once early in the summer, but continue to do so throughout the season and that it is usual for only one, and rare for more than two buds, to develop fronds from one rhizome-terminal per annum. If existing fronds are destroyed, however, these buds may be encouraged into growth and Smith points out that their growth will be proportional to the reserves still available in the rhizome. Grass quickly began to appear between the sparse fronds, doubtless manured in part by the decay of the former dead bracken, and sheep were attracted to the area in such numbers that they were constantly destroying the young fronds in the brittle hooked stage. With the disappearance of the bracken the grass still available sprang up so luxuriantly that the area was recognisable at a distance of two miles by its brilliant green colour. Sheep also flocked into it. In 1929 a few small fronds only 6 to 8 inches high appeared and were speedily destroyed by sheep-treading or by the fungus, but the sparseness showed that the disease had been working in the rhizomes underground all winter. Obviously many of these were diseased as they were internally discoloured. With the exception of one corner all the area became devoid of bracken during the summer of 1929, but the decay of the fronds and rhizomes made the sparse vegetation of heath bedstraw (*Galium aparine*), annual meadow-grass (*Poa annua*) and Yorkshire fog (*Holcus lanatus*) inadequate to withstand the effects of erosion by the water flowing down the hill, especially as sheep were constantly moving on the area. Much of the peaty layer of 6 to 7 inches overlying the rocky or clayey soil was thus swept away. In other places where fiorin (*Agrostis spp.*) was dominant, the grass benefited so much by the manurial action of the rotting bracken that it "closed up" excellently. Common rush (*Juncus effusus*) was abundant and at first tended to invade. It was therefore clear by 1930 that the eradication of bracken in itself is insufficient if the area is to suffer erosion or merely to carry

weeds of no greater value than the displaced bracken. Efforts made to remedy this state of affairs have received considerable attention at Garelochhead and will be described elsewhere.

Since 1928 the attack has steadily continued. An area which then showed signs of the disease succumbed in 1929 and a nearby area died in 1930. In 1930 the disease was most marked in a place half a mile to the north. These areas have been mapped out and studied in greater detail, but the work is not yet completed.

(*b*) Stems suffering from the non-virulent strain show the black spots or brownish lozenge or oval marking which often contain pustules (*pycnidia* or *perithecia*). Similar pustules appear on the upper surface of the browned and distorted pinnæ in a manner comparable to those virulently attacked, but the disease does not proceed so rapidly nor strip the frond so completely of foliage. Good examples of this type of the disease from Roundstonefoot, near Moffat, are shown in Fig. 2 of Mrs Mary F. J. Gregor's paper (5), and a general view of both types of attack in Fig. 1 in a previous paper (1) by Mrs Alcock and the author. In the latter a list is given of the various places which were originally examined.

While on the one hand virulent attacks are destructive and lead to the death or the disappearance of the bracken, it must be remembered they are definitely local. The possible factors which localise them will be discussed in a later paper. On the other hand, non-virulent attacks are difficult to classify by the results they produce, as these vary so much.

That the disease cannot be left to exterminate the bracken unaided is very clear. In the original diseased area at Garelochhead, besides the knoll which has never become extinct, there was a small patch of fronds which although reduced to very tiny fronds never succumbed. In 1929 they apparently benefited from the manurial matter set free in the slope above them (they lie in a hollow) and they increased and continued to increase in vigour, size and number (from about 300 tiny fronds in 1929 to over 1300 in 1933). In 1929 it would have been quite easy to have exterminated the lot —one cutting would probably have done it. Now it would require a number of cuttings and I have no doubt that ultimately this patch, if left to itself, could in time recolonise the three-quarters of an acre which the disease of 1928 cleared. Mr C. Christison, Ardtornish, Morven, Argyll, has shown me a similar recolonised area. The moral is obvious. *When bracken is weakened by natural means, every effort should be made to ensure that every vestige of bracken is exterminated.* It is also well to remember that by digging a narrow trench only as deep as the underlying hard soil, the passage of the bracken rhizome can be checked and its area delimited. In most of the cases suffering from "Garelochhead disease" the rhizomes are only a few inches, 6 to 8, below the surface.

In the above it has been assumed that the spread of bracken is by means of the increase of its underground stem or rhizome.

Sporelings certainly are sometimes produced, but they are seldom seen and for the present paper we will assume that they are rare in exposed sheep-walks. J. W. White (11) has cited some of the best known instances of their occurrence.

4. **Milngavie Type of Disease.**—*Corticium anceps* (Bres. and Syd), Gregor.—In 1927 an undoubted fungal parasite on bracken was found under shelter of trees in Craigallion Wood, near Milngavie, Dumbartonshire. A white, felty mycelium thickly covered the lower sides of the pinnæ and to a less extent portions of the upper rachis. Later, numerous cushions of infection were produced on the adjacent pinnæ in which ultimately white spherical bodies formed, which before winter turned to brown sclerotia—a dormant resting stage. No fructifications were found at the time. The fungus was proved to be a parasite by the way in which mycelium could be made to pass from infected pinnæ to healthy material placed in contact under moist conditions. The pinnæ were rapidly killed, the brown areas being sharply delimited from the healthy tissue and the dead material rapidly "dried up" and fell off, leaving the fronds markedly lop-sided and irregular. The area was marked out for future reference, and although the bracken has not been exterminated in the spot it is distinctly unhealthy and at least other six patches have developed within a mile of the original one.

The fungus grew freely in culture, producing large-celled hyphæ on which vesicular swellings occurred in great numbers. Sclerotia were also produced. Mr A. E. S. McIntosh, B.Sc., called attention to the resemblance to *Hypochnus ochroleucus* Noack, but in no case were recognisable basidia obtained. Both in Edinburgh and in Glasgow the extracted fungus gave positive results when re-inoculated into healthy bracken *under laboratory conditions*, but in the open field results successful for a few days were negatived by the end of a fortnight. Although Dr. F. T. Brooks, F.R.S., suggested *Corticium spp.* in 1927, it was not until 1931 that Miss E. Wakefield, M.A., of Royal Botanic Gardens, Kew, confirmed this, having obtained fructifications and identified the fungus from material from near Belfast. Another gathering was collected by the author from excellent examples at Ardshiel, Argyll, by the courtesy of the late Mrs Cameron, and identified by Mrs Mary J. F. Gregor, Ph.D., Edinburgh University, who has determined the exact systematic position of the fungus (*Corticium* (*Tulasnella*) *anceps*) (6) and studied it. Dr Gregor also collected this fungus near Dunoon. As far as I am aware there are only five sites at present known of this fungus in Great Britain and Ireland—near Dunoon, Ardshield Policies, Montcoffer Woods (Banff), Craigallion (Milngavie) and near Belfast. Three of these are known to me and agree with Miss Wakefield's description of the Irish Station in being under the shade of trees. If we could obtain a virulent strain of this fungus growing in the open, it might be very helpful.

The Difficulties in the Isolation of the Bracken Fungus.—The recognition of fungi in bracken is a much more complicated matter than is apparent at first sight, for ferns (like many other plants) possess internal mycorrhizal fungi of doubtful beneficial character. Peyronel has shown that these may be of a composite nature, one of which has phycomycetous characters. These internal fungi are notoriously difficult to isolate and "culture." In 1926, Dr W. G. Smith suggested that the Knoweside fungus might be a mycorrhizal one gaining the upper hand and the following year Dr. M. C. Rayner (9) called attention to Dr E. M'Lennan's work on the presence of mycorrhiza in Australian bracken. At a meeting of the Edinburgh Botanical Society on 17th May 1927, Mrs Alcock demonstrated the presence of endotropic mycorrhiza in the roots of bracken and suggested the possibility of an endotropic mychorrhiza that is quickly digested and a second ectotropic one, darker, more septate and more enduring. Mr W. F. Burnett, B.Sc., showed that apparently healthy bracken possesses cells in the frond punctured by fine, internal mycelial strands, but it has not yet been possible to determine the nature of these. Moreover pieces of externally sterilised bracken rachis from apparently healthy fronds developed fungoid growth in sterile water. The presence of fungi in the bracken therefore means nothing. It must be isolated and made to re-infect healthy bracken before we can be sure that we have a pathogen. The separation of the diseased fungus from the normal cell inmates has so far proved extremely difficult. On one or two occasions material which produced infection in the laboratory was useless in healthier material in the open.

A number of fungoid diseases which attack ferns have alternate hosts on trees and other plants. The possibility of bracken fungi infecting other plants during part of their life history has, therefore, been borne in mind, but with the exception of *Corticium anceps*, which was once found on the Male Fern, the diseases so far investigated have not been found on plants other than bracken.

Conclusion.—Presumably some factors are making the bracken susceptible to diseases. It is suggested that much of the Scottish bracken is now living in unsuitable sites, where a very slight deterioration of the conditions makes it prone to diseases, and susceptible to normally weak parasites. Observations suggest that unsuitable soil and frost may be such factors. Excessive moisture in the soil also appears to be harmful. It is not yet clear whether this is due to a definitely inhibitory action of the water on the rhizome development or merely due to the leaching of essential bases from the soil. We know, for example, that bracken makes large demands on potash (3).

Summary.—Summing up the history of the bracken diseases to date, four types can be recognised. (1) "Hook Disease"; (2) Knoweside Type, possibly a decline disease, where no actual organisms are traceable and which may be a phase of type 3 or due to a complex of other factors (exposure, climate, soil, insects, etc.); (3) Gareloch-

head Type, which has been the most active destroyer of bracken on a large scale. The organism so far has not been isolated. It has been suggested that it is not a normal parasite, but may be a saprophyte which becomes a facultative parasite when the bracken is weakened by external factors. This would explain its sudden appearance over widely scattered areas. Saprophytes which become facultative parasites might presumably provide extra-virulent races, so an outlook for a virulent parasite must be maintained; (4) Milngavie Type, where a definite parasite (*Corticium anceps*) has been demonstrated. This seems to prefer damp, shady surroundings and so far, inoculation experiments in the open have been unsatisfactory.

Acknowledgments.—As mentioned earlier, Mrs N. L. Alcock, Edinburgh, has been associated with me in the mycological investigation since the inception. Without her enthusiasm and whole-hearted co-operation, work could not have continued; moreover she kept up experimental work when classes made it impossible in my department. Under her guidance valuable assistance was forthcoming from Dr Foister, Mr A. E. S. McIntosh, B.Sc., Mr R. R. Clarke, B.Sc. Later a grant from the Development Commission made it possible to employ Mrs Gregor, Ph.D., for a year on the mycological side under Mrs Alcock's supervision. Mr W. F. Burnett, M.A., B.Sc., and Miss E. P. Barnett, B.Sc., of my own department tackled certain aspects of the subject and we were assisted for a year by a grant from the Development Commission whereby we were enabled to set up an experimental station at Garelochhead and employ Mr T. F. Stoddart, N.D.A., on ecological and mycological investigations. This work is now being made ready for publication. My heartiest thanks are due to Sir Iain Colquhoun, Bart, D.S.O., Mr Wm Russell and Mr Wm Hamilton for facilities to work at Garelochhead and for assistance with fencing, etc., to Sir Arthur Hill, K.C.M.G., F.R.S., Director of Royal Botanic Gardens, Kew, Mr J. D. Hosie, Banff, and also to others already mentioned.

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Further Studies in the Prevailing Diseases of Poultry

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In a previous article (1) in this *Journal* the writer dealt with certain prevailing diseases in flocks of poultry which had been under observation for a period of six years, the necessary data being obtained from the post-mortem and other records of the flocks at the Scottish Egg Laying Test. Each of the five diseases then described had occurred in each of the six years of observation, but one only—tuberculosis—was definitely associated with a germ. In continuation of these observations, the present paper deals with three other diseases—leukæmia, peritonitis and rupture of the liver —which occurred in five out of the six yearly periods. Each year of observation commenced on 15th October and was divided into twelve periods of four weeks each.

Leukœmia.—During the six years of observation fourteen cases of leukæmia occurred, but there was no case during the fifth year.

This figure represented six per cent. of the total number of deaths from all causes and 0·42 per cent. of the total number of fowls under observation over the whole period. There does not appear to be any particular period of the year when the disease is more prevalent than at another.

Scrutiny of the pen records of the disease showed that ten pens had a case of the disease once ; and only two pens, H and N, were affected more than once.

Pens·H and N were widely separated, but a case occurred in pen H one year and in pen N the next year and in both H and N the following year. There was thus an interval of two years between the cases in pen H and about eighteen months between the cases in pen N. The two pens in closest proximity which had a case of the disease were separated by a pathway and the interval between the cases was more than three years.

In this connection it is important to notice that there was never more than one case in a pen in any one year—that is estimating the number of cases by the number of deaths from the disease ; if any other fowl in the pen were affected it showed no sign, nor did it die of the disease during the observation period. This observation confirms the statement of Kaupp (2): "It is probable that the disease is not readily transmittable under natural conditions."

Cases were fairly scattered among the commoner breeds, involving five out of the twelve breeds represented.

Peritonitis.—7·8 per cent. of the total number of deaths—0·54 per cent. of the total number of fowls under observation—was attributable to peritonitis. Eighteen cases occurred during the six years, but there was no case during the third year. Cases were more numerous in the second halves of the years of observation.

With regard to the incidence of the disease in the pens, the following facts are of importance. Fourteen pens had a case of the disease once, and two pens only had a case more than once.

These two pens, S and B, were situated far apart, and there was an interval of three years between the cases in each of the two pens. There was never more than one death from peritonitis in one pen in any year of observation.

Pens C and D were adjacent and were affected with one case each in one year, but there was only one case in each pen. These facts suggest that the disease, however acquired, does not tend to spread among the pen-mates of the affected fowl.

Of the twelve breeds represented five showed cases of peritonitis.

Rupture of the Liver.—The cases to be considered here are cases of rupture of the liver not preceded by fatty degeneration or by tuberculosis, either of which frequently terminates in rupture of the liver and a fatal hæmorrhage.

Apart from the first year, there was one case annually; with one exception the cases occurred in the second halves of the years of observation.

Rupture of the liver with fatal hæmorrhage accounted for 2·17 per cent. of the total number of deaths and for 0·15 per cent. of the deaths among the total number of fowls. The pens showing cases of the disease were widely separated and no pen had more than one case of the disease, and no pen was affected more than once.

The disease is not apparently influenced by the feeding as it occurred with different dietaries. The condition was restricted to the White Leghorns, Rhode Island Reds, and White Wyandottes—but these were the most numerous breeds represented.

Acknowledgments are due to Mr J. E. Wilson, B.Sc., M.R.C.V.S., for his assistance in connection with the post-mortem examinations, and to the Department of Agriculture for Scotland for permission to publish the paper which is based upon an analysis of the excellent reports published by the Department in connection with the Scottish Egg Laying Tests.

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Provision of Plots for Unemployed Miners and Others

THE Department of Agriculture for Scotland have had in operation during 1933 and this year an experimental scheme for the provision of small plots of land for cultivation by unemployed miners and others, and it is the purpose of this article to give a

brief description of the scheme and to indicate some of the results achieved.

Towards the end of 1932 the Department set on foot enquiries with a view to ascertaining, firstly, the extent of the demand among unemployed miners and others for plots of land, of a quarter of an acre to one acre or thereby in extent, in the vicinity of their homes, with the object of relieving them from idleness and enabling them to produce food for their own tables; and, secondly, the possibilities of meeting that demand. The results of these enquiries were encouraging and it was decided to make the experiment. The successful introduction of the scheme would have been more difficult had not the Department received the active support of miners' leaders, Members of Parliament, Local Authorities, social workers, and others, many of whom rendered valuable assistance and did much useful work in making the purpose of the scheme known in the counties of the industrial belt.

The size of the plots provided varies from one quarter of an acre to one acre or thereabouts. Each plot can be developed as a self-contained unit, and gives its occupant an opportunity not only of raising potatoes, vegetables, and small fruit, but also of rearing poultry, pigs, or rabbits. These plots thus fulfil a different purpose from that of allotments by catering for unemployed men who incline towards more extensive and varied activities on the land than are possible on an allotment. The scheme therefore does not enter into competition with, nor is it intended to be in substitution for, the allotment schemes of Local Authorities or those aided by the Joint Committee of the Scottish National Union of Allotment Holders and the Society of Friends, or other organisations for the provision of these small-sized allotments or allotment gardens (generally about one-sixteenth of an acre of land) which may be the recipients of Government Grants through the Department. The land is generally acquired by the Department on lease for a period of 5 years. The plots are let by the Department to applicants on yearly tenancy, the rents charged being calculated to recoup the Department for their outlays while not imposing too heavy a burden on the tenants. The rents payable by plot-holders have so far varied from 6d. to about 1s. 3d. per week per acre, but the men are relieved of any rent charge during the first year of occupancy. The Department further assist the men by providing necessary plants and seeds, tools and fertilisers (but not live stock), for which payment is recoverable by small weekly instalments, collection being deferred but beginning not later than the commencement of the second season of occupancy.

While it has been the intention that the scheme should be available for any district where a demand for plots exists and where suitable land can be obtained on reasonable terms, practical considerations (chiefly the distance of the men's homes from available land) have limited the introduction of the scheme in cities

and large towns, and the Department's activities have in consequence been directed generally to dealing with applications from mining and other semi-rural districts where unemployment exists.

During 1933 the Department provided 120 plots at 10 centres in Ayrshire, Dumbartonshire, Fifeshire, Lanarkshire, and the Lothians. The total extent of land leased for the purpose was about 90 acres, made up of areas varying from 3 to 31 acres. The demand for plots continued and increased, and it was decided to extend the scheme for a further season. During this year a further 492½ acres of land have been acquired on lease at 49 centres, on which 644 men have been placed.

The following summary indicates the extent to which the scheme has been developed since its inception in the 11 counties in which the Department have leased land :

County	Number of centres	Total area (acres)	Number of men to whom plots have been let	Occupations
Ayr . .	11	28¾	62	Chiefly miners
Clackmannan	1	5	7	Miners
Dumbarton	4	28	37	Miners, shipyard workers
Fife . .	13	141	158	Do. do.
Lanark .	11	144	192	Chiefly miners
Midlothian .	4	104	100	Miners, shale workers
West Lothian	7	47¼	91	Do. do.
Peebles .	1	14½	15	Millworkers, labourers
Renfrew .	4	44	65	Labourers, calico printers, iron-moulders
Roxburgh .	2	20	25	Millworkers, labourers
Selkirk .	1	6	12	Do. do.
Totals .	59	582½	764	

It is too early yet to analyse the results of the scheme, but from the reports received by the Department it is clear that in the majority of cases the men have worked their plots with commendable energy and considerable success. One or two examples may be quoted from reports regarding the produce from the 120 plots formed in 1933.

At a scheme in Lanarkshire, where 22 plots were formed on 15½ acres, the plot-holders, who erected the fencing material supplied by the Department and laid out paths and dug tracks for water-pipes, raised about 50 tons of potatoes as well as other vegetables such as cabbages, sprouts, beans, peas, turnips, beet, onions, leeks, and lettuces; eight of the men had between them 132 head of poultry, two bred rabbits, and one had 2 pigs.

At a West Lothian centre comprising 14 plots on 5¼ acres the men mostly cultivated the ground in preference to keeping live

stock, although in two cases poultry were kept. Two men kept pigs for fattening. The crops grown included potatoes in all cases (about 14 tons were produced) and almost every variety of garden vegetable. The cropping was very successful and good yields were obtained.

Poultry keeping proved successful on two Ayrshire schemes consisting of 12 plots. A report received in the early part of this year indicated that six men were producing weekly 2½-3 dozen, 5-6 dozen, 7-8 dozen, 11 dozen, 12 dozen, and 17-18 dozen eggs respectively. In addition about 10½ tons of potatoes were raised as well as a selection of garden vegetables.

The majority of the men, for whom plots have been provided this year, are concentrating on the growing of vegetables and the keeping of poultry. In some centres, notably in Lanarkshire, it seems likely that the growing of fruit such as strawberries and raspberries will be developed. The general progress made by the men has been encouraging and appears likely to justify favourable reports at the end of the season.

The tenants of many of these plots are men of later middle age for whom the prospect of return to their normal employment is remote. Others, younger men, may have better prospects of being reabsorbed into industry, but are none the less equally turning the cultivation of their plots to good account. The possession of a plot is regarded by most of the holders as a matter of much satisfaction, and some, especially among those who, although unemployed, have not entirely used up their savings, have expressed the desire to settle permanently on the land. Largely on their own initiative the men have been able in many cases to secure the material for the erection of poultry houses, pig pens, etc. Local sympathisers have also assisted with gifts of money or materials, and in various ways the assistance provided by the Department has been supplemented.

The men have been encouraged by the Department to work in association with their fellows in each group, and to appoint one of their number to act as secretary for the purpose of receiving supplies, collecting rents, and conducting any correspondence with the Department. The Department's Land Officers and the Instructors on the staffs of the Agricultural Colleges are continuously in touch with the men to advise them regarding methods of cultivation, choice of seeds, use of fertilisers, and any other matters affecting their plots.

Land Drainage

Observations on the Effects of Lowering the Level of a River

In the course of preparing schemes of drainage under the Land Drainage (Scotland) Act, 1930, and for that purpose systematically watching the behaviour of rivers in flood, the Department's

engineers have acquired experience to an extent probably never before attained in Scotland of the dynamics of water flowing in the channels of rivers. In this way light has been thrown on certain problems and some current conceptions have been corrected.

This may be illustrated from discussions regarding the probable effect of carrying out a proposal to blow up certain rocks in the River Annan at Dormont near Lockerbie, which have acted as a dam and caused the flooding of several hundred acres of meadow land above the rocks.

The object of the proposed drainage works was (1) to relieve from risk of flooding the area usually inundated in times of heavy rainfall; (2) to improve the gradient of the river (the two things being connected).

These proposals were criticised on the ground that

(*a*) the result of all the water flowing down the channel during times of heavy rainfall will be to add to the volume, augment the maximum discharge, increase the velocity, and aggravate the erosive action;

(*b*) the increased gradient will give a much increased velocity, resulting in increased erosive action.

The argument underlying (*a*) of the two criticisms assumes that the inundation of neighbouring land relieves the pressure of the flood water on the actual channel of the river. Actual observation, however, of the River Annan and of the River Kelvin, where similar conditions exist, shows that the areas which flood commence to do so long before the height of the flood, and continue to do so long after the height of the flood. It is true that the effect of such flooding is slightly to level the peak of the flood in the upper reaches. Unless there is a break in the banks the rate of flow into these areas is slow, and the duration of the flow is many times the duration of the flood maximum in the river. Little relief is obtained in the river, and such relief as is obtained under the conditions hitherto existing in the Annan will be effectively balanced by the regularisation of conditions when the work of removing the rocks is finished. Such flooded areas, flooding at random, are in no way equivalent, as some have suggested, to a reservoir area which might be designed, suitably fitted with valves, for the purpose of giving relief at critical times.

As regards (*b*) it is true that the gradient of the Annan after the works are executed will be steeper than before and, given a velocity of 6 to 7 feet per second in flood, the velocity will be somewhat greater than the present flood velocity.

The general theory underlying the reply to the criticisms may be stated in the following terms.

The theoretical velocity of water flowing in an open channel has a relation with the gradient of the surface of the water proportionate to the square root of that gradient, and only a remote

(if any) relation with the gradient of the bed of the channel. The standard formula expressing this relation is $V = C\sqrt{\frac{A}{p} \times \frac{h}{l}}$,

where V = Velocity.
C = Coefficient of rugosity.
A = Cross-sectional area.
p = Wetted perimeter.
h = Rise or fall in inches.
l = The length of section of river.

The result of applying this formula will show that a 125 per cent. increase in the steepness of the gradient only results in a 50 per cent. increase in velocity.

For the sake of illustration one may take a point in a channel at a level of 100 feet above Ordnance Datum. Under normal conditions the surface gradient of the water in that channel will have a constant value.

On the admission of an increased quantity of water into that channel (*i.e.* a flood), *immediate* discharge of the increased quantity *does not* take place, but is postponed until the water rises in level, thereby increasing the cross-sectional area (*i.e.* the width of channel × the mean depth).

Such rise is more or less gradual in relation to space and increases as we go upstream, thus increasing the gradient.

Upon the rise reaching a given level, spilling and flooding of the adjacent land takes place.

The effect of spilling or flooding at an upper reach of the river under the assumed conditions is to retard the rise in level *at the point where the overflow takes place*, but it does not affect the relative rise (and therefore velocity) in the lower reaches, and if the overflow were prevented by flood banks it would result in a steeper gradient *at the point of overflow*, the degree of steepening depending on the intensity of the rainfall.

It may be conceded that as a result of the steepening of the gradient there follows an increase in the velocity, but this is of small degree, as was illustrated earlier in these notes.

The general theory as outlined above is based on the assumption that a sufficient channel has been provided capable of dealing with the assumed flood condition, and this is the basis on which the works on the River Annan have been designed.

Some observations may be made on the process and effects of the erosion of river banks. Two types of case may be distinguished, *i.e.*

Case (1) Where the flood level never rises above the surrounding lands; and

Case (2) Where the flood level does rise above the surrounding lands.

Case (1) is much the simpler. If erosion takes place its effects are immediate; they are not far-reaching and the loss is limited to the area actually eroded. Generally the cost of prevention of erosion as such is not worth the result obtained, and it may be asserted as a general proposition that where rivers flow through agricultural land in Scotland, and where the flood level does not reach the surrounding land level, protection of the natural banks is seldom to be found, unless for the preservation of buildings or bridges, for the benefit of fishing or for the preservation of a defined channel for a sluggish small stream.

Incidentally it is to be noted that where erosion does take place the cross-section of the stream is increased (which point is of fundamental importance in connection with velocities in a channel) resulting in a decrease of velocity and a subsequent balancing of conditions.

Case (2) is quite different. For the same class of material as in Case (1) the erosion is much greater. Once over the top the flood takes the line of least resistance and scours on the top, cutting into the soil in much more severe fashion than where it is attacking below surface level. Two concrete examples, at the Kerricks break on the River Nith, and at the Queenshaugh break on the River Spey, can be cited in support of this statement. Observations at these two points show that when the flood rises above surface level the erosion increases very quickly. This is the immediate effect to compare with Case (1). But the results are much wider than this immediate effect. The flood destroys crops, is a menace to stock, scours out subsidiary channels and deposits debris. To counter this the measures adopted are channel improvement or the construction of artificial flood banks. When flood banks are built they are either placed far enough back to allow of a generous margin for possible erosion or, if the margin is small, the natural banks which then form the "toe" or "footing" of the artificial banks are protected. This is when the protection of the natural banks is so very important.

The conditions in the Dormont stretch have natural banks with artificial banks close behind them. The river in flood time rises above field level. The natural banks have been protected at places, but the protective measures have, in general, fallen into disuse. The protective works were not for the banks in themselves. They form the footings for the artificial banks which, in turn, are the defensive bulwarks for the large areas behind.

After the Rocks work is completed the flood level will be below field level. The need for artificial flood banks will have disappeared, and the need for protective work at the natural banks will in turn disappear. The Dormont lands will no longer be governed by the conditions of Case (2). They will be governed by the conditions of Case (1).

Reviews

Rural Britain To-day and To-morrow. James A. S. Watson. Oliver & Boyd, 5s.

Those who were fortunate enough to "listen in" last winter to Professor Scott Watson's series of broadcast talks on his impressions of British farming, as he saw it on his journeyings in various parts of the country during the summer, will be glad to have this permanent record of them. Professor Watson calls his peregrinations "A Modern Cobbett's Tour." But whereas his prototype made his way through the country on horseback, his modern imitator gets about in "an old motor car." The contrast is significant of the changed times. The mechanised transport certainly enables Professor Watson to extend his survey much more widely and to see more varied farming conditions in much less time than his bluff, John-Bull predecessor could compass in his *Rural Rides*.

One gathers from Mr Walter Elliot's characteristically enthusiastic introduction that Professor Watson's tour was undertaken with the special object of getting first-hand impressions of present-day farming conditions in the different parts of the country traversed, and then of describing these to the listening public in the hope of creating in the mind of the townsman an intelligent sympathy with his rural brother in his struggle to make ends meet in these difficult times. For the purpose intended no better selection of an observer could have been made than that of the Sibthorpian Professor of Rural Economy in the University of Oxford. Professor Watson is not only an acknowledged authority on the academic, scientific side of agriculture; he is a practical farmer, having an intimate personal acquaintance with its difficulties and its possibilities; and he has, moreover, a gift of simple, direct and, withal, literary expression which makes it a pleasure to read his account of things seen, and which gives point to his opinions on the many problems confronting farmers in all branches of the industry.

His journeyings on this quest covered all the important farming regions of England, Wales, and Scotland. He views with seeing eye and understanding mind the pastures alike of Romney Marsh and of the West Highlands; the dairying districts of Somerset and Wiltshire and those of Galloway, the Stewartry, and Ayrshire; the cattle-rearing dales of Cumberland and the glens of Banff and Aberdeen; the corn-growing acres of Norfolk and Angus and the Lothians; the potato fields of Eastern Scotland and Eastern England; the market gardens of the Evesham neighbourhood, the orchards of Hereford and Kent, the vegetable and flower farms of Cornwall and Devon, the tomato-houses of the Clyde; and the

distinctive characteristics of many other localities with their special lines of production.

The human factor is given its proper share of attention, and the attitudes of landlord, big farmer, small-holder, and farm-worker are represented with knowledge and sympathy. Professor Watson fully appreciates the influence of woman on the whole round of farm-life and the immense value of her work, and he expresses sincere admiration for what the Women's Rural Institute movement has done for the countryside.

Naturally, he is interested in education, and he discusses its problems with his friends in a wise and helpful way. One is tempted to wish that many more rural schoolmasters were gifted with as much originality and initiative in their methods as Mr Rayment of Hertinfordbury.

Descriptions of the activities of the various research stations visited give a clear indication of how these institutions are working to help the farmer by the production of new varieties of crops, by increasing knowledge of the processes of nutrition, by controlling diseases and pests of plants and animals, and in many other ways.

The development of mechanical means of cultivation, harvesting, and transport is observed and described in several notable instances, and large scale farming in different lines has its exemplars noted and its future possibilities discussed. Modern attempts at reorganisation of marketing farm products come under notice, and Professor Watson's opinion of them is on the whole hopeful. He is less inclined to favour indiscriminate extension of small-holdings, mainly because he regards any success they may attain as being too dearly bought by the intense application of family labour.

There are many other subjects on which Professor Watson's views are worthy of consideration, and one is glad to find that in spite of present troubles he is optimistic about the future and is enthusiastic enough to think farming still the best of lives for men and women to lead.

The book is one which should be on the shelves of all who are interested in British farming.

The Agricultural Register, 1933-4. Issued by the Agricultural Economics Institute. Oxford, 3s. 6d.

The reason for the publication of this handbook—as explained in the preface—is the rapid change that is taking place in the economic conditions of agricultural production in this country. The crisis had become so acute that State interference was urgently demanded, and the resultant action has been so all-pervading that "it amounts to a considered plan for the entire reconstruction of the industry in some of its most important functions and a complete revision of economic relations with other countries."

When one remembers the multifarious details of the Agricultural Marketing Acts, the Import Duties Acts, the Ottawa Agreements Act, the Agricultural Produce (Grading and Marking) Acts, and the numerous schedules and schemes that follow upon these, the need for some comprehensive compendium of information in regard to them becomes amply evident. The *Agricultural Register* sets out to provide such a book of reference to these and other measures that have been adopted in the attempt to save the agriculture of Britain from economic ruin. The *Register* has been compiled by the staff of the Agricultural Economics Research Institute at Oxford, and the intention is to make it an annual publication if the circumstances of the times and the wants of the public appear to call for it.

To the general reader the most interesting portion of the book is likely to be the opening section in which are discussed the principles of the new agricultural policy. The nation has endorsed the plan of protection for home industries—on the condition that the industries concerned reorganise, as far as possible, the production and distribution of their output, and this has been applied to agricultural commodities by the passing of the Agricultural Marketing Acts, 1931 and 1933. The earlier Act provides the means of organising the distribution and sale of a commodity according to the wishes of a majority of the producers, any dissentient minority being compelled to acquiesce. The 1933 Act supplements these powers by giving authority to the State to limit the quantity both of import and of home production of a commodity. In purpose the Acts are an attempt to secure organised marketing, regulation of supply, and economic development of remunerative branches of agriculture.

Schemes for the organisation of the marketing of particular commodities may originate either with the producers or with the Government Department concerned, and in details and in methods of attaining the end in view they naturally vary. The methods adopted range from subsidy, in the cases of sugar-beet and wheat, to a high tariff and a price-fixing agency in that of hops, a trade agreement on prices between producers and distributors in milk, calculation of production costs in bacon, and limitation of production in potatoes.

It is pointed out that the problem of the nation is to see how these policies can be applied without reducing farming efficiency and without exploiting the consumer, both of which ends were attained in some degree under the old free competitive system or lack of system.

The *Register* gives full details of the legislative enactments involved in the new policy, of the Ottawa and other trade agreements, and of the procedure adopted under the various marketing schemes so far put into operation—hops, milk, bacon, pigs, and potatoes.

For a full understanding of the British position in relation to world markets an account is given of movements in prices and supplies of the more important agricultural products in recent years, and of the various trade agreements that have been made in respect of supplies of these products to Britain, both from the Empire and from such foreign countries as the Argentine, Denmark, Sweden, Holland, and other Continental countries. The special case of the Irish Free State is noticed as dealt with under the Irish Free State (Special Duties) Act. Regulations affecting the importation of fruit and vegetables are summarised and the effects indicated so far as observed.

Supplies and prices of fertilisers and feeding stuffs in 1933 are quoted, and prominence is given to the arrangement come to by the Millers' Association whereby farmers will in future be able to purchase milling offals of standardised quality with a guaranteed maximum fibre content.

Two brief sections deal with statistics of crops and grass and live stock, and with labour supply, wages, and unemployment insurance proposals. Miscellaneous subjects include an account of the weather of the year under review and a note regarding the provision of agricultural credit.

The *Register* professes to deal only with matters affecting England and Wales. Scotland and Northern Ireland come into the picture only where these countries are concerned jointly with England and Wales.

It will be gathered that the *Register* is a most useful compilation as a book of reference for facts relative to the attempts now being made to resuscitate British agriculture.

Farm Machinery. A. A. Stone, New York Institute of Applied Agriculture. Chapman & Hall, 18s. 6d.

In these days of mechanisation of industry no one will deny that an adequate course in Farm Machinery is an essential part in the curriculum of an agricultural college, or that for the modern practical farmer some knowledge of farm mechanics is essential. The farmer should at the least be sufficiently skilled to know when his implements and machinery are working efficiently, and he had better be able to make the necessary readjustments and to fit spare parts when wanted, in order to get the best returns from his outlays on equipment.

This text-book sketches out a course suited to the needs of the American Agricultural College student, and its directions, with accompanying sketches, likewise provide a useful *vade mecum* for the American farmer.

But although it is an American publication and naturally deals with American types of implements and machines suited to overseas conditions, the matter and the method of presentation are

both worthy of study by all teachers of the subject in this country, and one can imagine them getting many useful hints that will be helpful to them both in their theoretical instruction and in their workshop practice.

The first part deals with farm implements—ploughs, harrows, seed-drills, cultivators, mowers, binders, manure spreaders, potato planters and diggers, and threshing machines. The second part treats of power engines, tractors and their parts, magnetos and ignition, the locating of engine troubles, and repairing.

The instructions given are precise and definite and the language plain and pointed, while the illustrations are numerous, clear, and helpful.

A feature of the treatise as a student's handbook is the series of problems which are set as laboratory studies on all the matters dealt with. A student who works conscientiously and successfully through the series ought to be a thoroughly reliable farm mechanic.

Suppression of Weeds by Fertilisers and Chemicals. H. C. Long, B.Sc. (Agric.) of the Ministry of Agriculture and Fisheries. With foreword by Sir A. D. Hall, K.C.B., LL.D., F.R.S. To be obtained from the author at "The Birkins," Orchard Road, Hook, Surbiton, Surrey. Price 2s.

The subject of this brochure has not been dealt with comprehensively in any previous British publication, and the literature in which it is mentioned at all may not be readily available to farmers. Moreover, although the author would doubtless admit that further investigations may, and probably will, result in considerable advances in the science of weed suppression, the time is opportune for the publication of a work which assembles, in a convenient form, the most important available information. Mr Long, whose writings on weeds are widely known, is well-qualified to undertake such a task.

The brochure, which contains many excellent photographs, is very interesting and easily read. The effect of different chemicals on weeds is not always the same, and, as pointed out by Sir Daniel Hall, three distinct types of action are recognised: weeds may be combated by altering the soil conditions, as happens, for example, when spurry is controlled by means of lime; some weeds may be killed by the direct action of chemicals on their foliage, *e.g.* charlock destruction by sulphuric acid; and some chemicals, *e.g.* sodium chlorate, act as plant poisons. Mr Long is careful to point out, however, that the methods to be employed cannot be standardised, and depend upon many conditions, including crop, climate, quantity and nature of weeds, and water supply. The subject matter is systematically treated and each chemical is dealt with separately.

The book is written primarily for farmers, but it is sure to appeal to students and the general public. Should a second edition be contemplated at any time, it might be advantageous were an index to the weeds added to page 57, and the references put at the end of each section. It might be possible also to reduce the cost by the omission of some of the photographs.

The International Review of Poultry Science

The International Review of Poultry Science is a veritable mine of information for poultry-keepers.

It is edited by Dr Te Hennepe of the State Serum Institute, Rotterdam, and, as evidence of the efforts put forth by him to obtain information from every possible source, it is interesting to note that the Exchange List of this publication comprises about 100 periodicals which deal with general poultry matters, in addition to which Dr Te Hennepe, in virtue of his official position, has access to about 50 further journals from various countries, which deal more specifically with questions of disease and genetics. The result is that the *Review* is of the greatest value as a guide to the experimental work carried out with poultry throughout the world.

The *Review* is divided into sections, each including a short précis of all reports received on work done on each particular aspect of poultry husbandry. Information is also given as to where each report can be obtained. In this latter connection one ventures to suggest that it would be an advantage if in future issues some indication were given as to the approximate cost of each publication.

Interesting results are reported on work done and investigations carried out in connection with breeding, nutrition, physiology and anatomy, diseases, parasites, eggs and table poultry, while the general reports and those on egg-laying trials contain much useful information.

The International Year-book of Agricultural Statistics

THE 1932-33 edition of the *International Year-book of Agricultural Statistics*, published by the International Institute of Agriculture at Rome, consists of about 800 pages, and gives the results of the most extensive and detailed enquiry made in the domain of international agricultural statistics.

In the first part of the Year-book are classified the figures for area and population in the years nearest to 1928 and 1932 for 208 countries. The second part is composed of a series of tables comprising for nearly 50 countries the available data concerning the

uses for which the total area is employed, the apportionment of cultivated areas between the different crops, agricultural production, numbers of the different kinds of livestock and the products derived from them. In the tables constituting the third part of the volume there are indicated for nearly 40 agricultural products the area, production and yield per acre in each country during the five years 1924-1928 and during each of the years from 1929 to 1932.

For each kind of livestock all available figures in the different countries have been grouped for the years 1928 to 1932. A large part of the volume is devoted to statistics of the commercial movement of 43 vegetable products and 13 products of animal origin. The figures published relate to the imports and exports during the calendar years and for the cereals also during the commercial seasons.

The part devoted to prices contains the weekly quotations of 40 agricultural products on the principal world markets for the period January 1928 to July 1933. In the freights section will be found the quotations for the transport of wheat, maize and rice on the most important shipping routes, and in the section reserved for fertilizers and chemical products useful in agriculture statistics of production, trade, consumption and prices for 15 products are published. In the Appendix special chapters deal with the distribution of agricultural holdings according to their size and mode of tenure.

The volume is of the greatest importance to those interested in questions relating directly or indirectly to production and commerce of agricultural products.

Farm Wages in Scotland

As before, the Department issued with their Monthly Agricultural Reports for 1st January and 1st July supplements giving tabular statements of the estimated cash wages and value of perquisites given to the various classes of farm workers at the Martinmas and Whitsunday terms. Those statements are summarised in this article, together with comparisons with the rates current at Whitsunday 1933.

Where engagements between employer and servant were renewed, the remuneration generally was unchanged, but where new engagements were entered upon the tendency of wages was to move lower; in a few areas, however, competent men were paid at slightly higher rates owing in some cases to the services of less experienced workers being dispensed with.

The pecuniary values of the allowances given, in addition to cash wages, as reckoned at each of the three terms mentioned above, are as follows :—

	Whitsunday 1933	Martinmas 1933	Whitsunday 1934
Meal, per cwt. . . .	17s. 4d.	17s. 4d.	16s. 9d.
Milk, per gallon . . .	1s.	1s.	1s.
Potatoes, per ton . . .	£4, 10s.	£4, 10s.	£4, 10s.
Coal, per ton . . .	£1, 15s.	£1, 15s.	£1, 15s.
House, per annum . .	£6	£6	£6
Board and lodging for single men, per week . .	14s.	14s.	14s.
Bothy accommodation, with attendance, per annum .	£9	£9	£9
Bothy accommodation, without attendance, per annum .	£6	£6	£6
Keep of cows and followers, per cow, per annum . .	£10	£10	£10

The only item which shows a change in estimated value as compared with last year is oatmeal, the average wholesale price per hundredweight for the ten years ended 31st December 1933 being 16s. 9d. To men who receive 65 stone of oatmeal per annum, this would mean a reduction in remuneration of about 1d. per week.

The arithmetical averages of the Department's figures for the wages of married men are as follows :—

Average Weekly Earnings of Married Men

	Summer, 1933						Winter, 1933-34						Summer, 1934					
	Cash		Allowances		Total		Cash		Allowances		Total		Cash		Allowances		Total	
	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.	S.	D.
Ploughmen	26	5	8	3	34	8	25	7	8	5	34	0	25	10	8	3	34	1
Cattlemen	27	3	8	8	35	11	26	2	9	2	35	4	27	4	8	6	35	8
Shepherds	26	5	10	0	36	5	25	9	10	3	36	0	26	4	9	10	36	2

The total earnings in each case showed reductions at the winter term, but those decreases were partially recovered in the summer of 1934, the average advance in the total remuneration of married ploughmen being 1d. over the rates current in the winter of 1933-34, that of cattlemen 4d., and that of shepherds 2d. As compared with the average wage paid in the summer of 1933, however, a reduction of 7d. per week is recorded in the total remuneration of ploughmen, and 3d. in cattlemen's and shepherds' wages.

Married Ploughmen.—The following table gives in round figures the weekly earnings of married ploughmen in summer 1934, as compared with summer 1933, in respect of 38 out of the total number

of 49 counties and parts of counties included in the Department's wages statement :—

County or District		Summer, 1933			Summer, 1934		
		Cash	Allowances	Total	Cash	Allowances	Total
		s.	s.	s.	s.	s.	s.
Wigtown		23	16	39	23	16	39
Kirkcudbright		28	4½	32½	29	4½	33½
Dumfries		32½	3½	36	32	3½	35½
Selkirk		28	6	34	27½	6	33½
Roxburgh		28	6	34	27½	6	33½
Berwick		28	6	34	29	6	35
Peebles		31	4	35	31	4	35
East Lothian		29	3½	32½	29	3½	32½
Midlothian		30½	3½	34	30½	3½	34
West Lothian		31	3	34	31	3	34
Stirling		38	6½	44½	36	6½	42½
Dumbarton	Lower Clyde Valley	37	3	40	36	3½	39½
Lanark (N.W.)	Lower Clyde Valley	36	4	40	35½	4	39½
Renfrew	Lower Clyde Valley	33	4	37	33	4	37
Ayr (N.)		33	9½	42½	32½	6	38½
Ayr (S.)		32½	4	36½	32	4	36
Lanark (S.E.)		30	4	34	30	4	34
Clackmannan		34	3½	37½	32	3½	35½
Fife (S.W.)		34	3½	37½	32	3½	35½
Fife (N.E.)		25	12	37	25	9	34
Kinross		26	11	37	24	11	35
Perth (S.E.)		25	10½	35½	24	10½	34½
Perth (Central)		25	10½	35½	24½	10½	35
Angus (S.W.)		24	10½	34½	24	10	34
Angus (N.E.)		24	12	36	24	12	36
Kincardine		21	11	32	20	11	31
Aberdeen (E.)		20½	11	31½	19½	11	30½
Aberdeen (N.E.)		19½	12	31½	19	11½	30½
Aberdeen (Central)		18½	11	29½	17½	10½	28
Aberdeen (S.W.)		17½	11	28½	19½	11	30½
Aberdeen (N.W.)		18½	10½	29	18½	10	28½
Banff (N.E.)		20	10½	30½	19½	10	29½
Moray		20	11½	31½	20	11½	31½
Nairn		20½	12	32½	18½	12	30½
Inverness (E.)		20½	12	32½	18½	12	30½
Ross and Cromarty (E.)		18	13	31	18	12½	30½
Sutherland		17	14	31	17	14	31
Caithness		14½	15½	30	14½	15½	30
		s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Average		26 1	8 5	34 6	25 8	8 2	33 10

The arithmetical average of the cash wages for these 38 areas is lower than last year by 5d., while the value placed on the allowances or perquisites is lower by 3d. Three of the districts show a small increase in the cash wage, while in fifteen areas no changes have taken place, but in the other twenty districts reductions of from about 6d. to 2s. have been recorded.

The range of the total wages, including cash and allowances, in the various divisions of the country, is as follows: in the southern counties from 32s. 8d. to 38s. 9d.; in the Lower Clyde Valley from 36s. 10d. to 39s. 6d.; in the remainder of the central area from 33s. 3d. to 42s. 6d.; and in the north-eastern and northern counties from 28s. 1d. to 31s. 7d.

Single Ploughmen.—The average wage of single ploughmen in the south-eastern counties is 29s. 6d., or 11d. less than last year. In the south-western districts wages vary from 23s. in Wigtown to 28s. in Kirkcudbright. In the Lower Clyde Valley and North Ayr the cash wages average 15s. 5d. as compared with 15s. 8d. a year ago, with board and lodging valued at 14s. The average cash wage in the east-central division is 20s. 3d., or 1s. 4d. less than last year, while the allowances, valued at 6s. 4d., show a reduction of 3d. In the northern and north-eastern counties the average cash wage is 15s. 10d., and the value of the perquisites 12s. 1d. In Scotland as a whole a single ploughman's wage is 28s. 2d.

Women Workers.—Female dairy workers generally receive board and lodging, valued at 14s. per week, in addition to cash wages ranging from 9s. 3d. in Orkney to 17s. 4d. in North-West Lanark. In the Lothians and Peebles, where remuneration is wholly in cash, 23s. to 24s. per week is paid. Other women's rates, including board and lodging or their equivalent, vary between 21s. 8d. in Orkney and 29s. in South-East Lanark. Women paid by the day generally receive from 3s. to 4s.; in Wigtown, however, the rates paid range from 2s. to 3s., in South-East Perth from 2s. 6d. to 3s. 6d., in Angus from 4s. to 4s. 6d., in Stirling from 3s. to 5s., and in South-West Perth from 4s. to 5s. Women paid by the hour generally receive from 4d. to 5d.

Boys.—In most districts boys engaged for a six months' period receive cash wages in addition to board and lodging. The rates of remuneration vary according to ability and, where both are given, the estimated total wage usually ranges from about 20s. 2d. to 25s. In a few districts, where cash wages only are paid, the rate generally varies between 15s. and 17s.; some boys, however, receive only 10s. per week, while others are paid 18s.

Girls.—In the Lothians and Peebles girls generally receive 14s., in Kirkcudbright 15s., and in Roxburgh and Selkirk from 10s. to 15s. per week, with no allowances. Where board and lodging are provided, the estimated total weekly remuneration varies from 20s. 11d. to 26s. 8d. In Banff, girls are paid 3s. per day, and in North-East Angus, 3s. 6d.

Casual Workers.—Men are usually paid from 4s. to 6s. per day; in some instances the rate is as low as 3s., while in North-West Lanark 7s. 6d. is paid. Where engaged from week to week male workers generally receive from 26s. to 35s. Female casual workers are usually paid from 3s. to 4s. per day, or from 4d. to 9d. per hour.

Agricultural Conditions

THE weather during the first three weeks of March was wet, cold and stormy, with showers of snow and hail in many districts; night-frosts were frequently followed by piercing winds and spring growth was considerably retarded. Weather conditions improved during the last week of the month and excellent progress was made with ploughing and spring sowings. In south-western counties the rainfall during March was rather light for the season of the year, but was generally sufficient to raise springs to a more satisfactory level; in several north-eastern counties also conditions were rather dry. Wintry conditions prevailed throughout the greater part of April; the rainfall was very heavy and in many areas between the Tay and the Moray Firth severe flooding and damage to crops were reported. Farm work was greatly retarded by the sodden condition of the land. In parts of Angus oats had to be resown, while in parts of Aberdeen the land was too wet for seeding at the end of April. Low temperatures were general throughout the whole country during May, and in north-eastern and western districts the rainfall was heavy; ground frosts occurred in many areas and growth was checked by the cold weather and barren winds. In the central counties, however, dry conditions were general, and in Central Perth the lack of moisture was causing a shortage of water supplies at the end of the month. In most districts farm work was fairly well advanced, but in Kincardine considerable arrears had accumulated. In the last few days of May, however, weather conditions improved and prospects for crops were brighter.

Autumn-sown wheat wintered well, and at the beginning of April the crop generally was strong and thick in appearance. Growth was checked somewhat by the frosts and cold winds during March, and on many farms in the Lothians plants suffered from lack of moisture, while on inland farms in South-West Angus, and particularly on ground less suited to the crop, the condition of the plants was disappointing. Spring sowings of wheat were practically completed before the beginning of April. Good steady progress during April was reported, and at the end of the month the crop had a healthy and promising appearance in most districts. On many farms in Kincardine and Stirling plants were too thick on the ground, while in North-East Fife fields had to be thinned out and growth was checked by stormy weather. In Berwick, although plants were well forward, they had slightly lost colour through lack of heat, but

in the Lothians the crop did not thrive during April and was thin on the ground. Wheat made fair progress during May, but, with low temperatures and lack of sunshine during the month, the crop was rather backward in several areas. In a few of the principal wheat-growing counties some damage was done by insect pests and the severe weather conditions. In South-West Angus considerable areas were damaged by " Wheat Bulb Fly " and much of the crop affected was ploughed up, or barley was drilled in, while in parts of South-East Perth wire-worm was prevalent. In North-East Fife earlier sown wheat had a seared appearance and some fields were ploughed in. In Central Perth the crop was promising where sown after potatoes, but was unsatisfactory after turnips. Elsewhere wheat generally was looking well at the end of May. Estimates of the acreage sown indicate that in all the important wheat-growing districts the area under the crop has again been substantially increased, and it appears likely that the annual returns made on 4th June will show an increase in the area under wheat of about 11,000 acres.

Little interruption occurred in the preparation of the land for spring sowing and the seeding of barley made good progress during March; in the Lothians the work was completed under perfect conditions and in South-East Perth a start was made with some late sowings. Sowings were practically completed by the end of April, but in Kincardine some very late sowings were reported. Germination, while regular, was generally slow, and at the end of May rain and heat were badly needed in most districts for the development of the crop. In South-East Perth wire-worm was troublesome and in Central Perth grub and wire-worm were responsible for some patchy fields, but in south-western and some western counties plants were strong and healthy and had a fresh and vigorous appearance. Estimates of the area under barley this year indicate that there will be an increase amounting to about 1,500 acres in the total area under the crop.

The sowing of oats made good progress during March and by the end of April the work was nearing completion in most districts. In South-West Angus, however, much delay was caused by heavy rains and, where flooding had taken place, second sowings were necessary. In several eastern counties germination of oats sown in February was less satisfactory than among later sowings, but brairds generally looked healthy and promising at the beginning of May. Early sown oats made good progress during May, but where sown later growth was checked by the cold winds. On stiff land the crop was rather thin and patchy and generally plants were rather backward. In Central Perth grub and wire-worm caused fairly extensive damage, and in Wigtown some fields were cut by grub. Increases in the area under oats this year were reported in two districts only—North Ayr and Kirkcudbright—but substantial decreases were reported from Central and North-East Aberdeen, Ross, South-East

Perth, and the Lothians. So far as could be ascertained from estimates at the end of May it appears probable that the decrease in the total area under oats will amount to 20,000 or 25,000 acres.

At the beginning of June beans were reported to be a strong and healthy crop, were free from disease and insect pests, and did not appear to be adversely affected by the low temperatures that prevailed during May.

The preparation of land for potatoes was carried out with little interruption, and by the end of March the planting of earlies was practically completed in eastern, southern and south-western counties under favourable soil and weather conditions. The planting of maincrop varieties, while not general, also made satisfactory progress during the month and large areas had been planted in several eastern districts. The sodden condition of the land in many eastern and north-eastern counties greatly interfered with the work during April and on some farms in Berwick the work had not even commenced at the end of that month. In the Lothians, however, planting was practically completed under ideal conditions. Planting generally was completed during May, but in a few districts soil and weather conditions were by no means ideal for the work. At the beginning of June early varieties were through the ground in most districts, but growth was checked by the cold weather and the progress of the crop was less rapid than at that time last year. In the Lothians and North Ayr second earlies were filling the drills, but maincrop varieties were slow to break through. The crop generally was reported to be strong and healthy. Estimates of the area planted indicate that the total acreage will be slightly smaller this year and will be about the same as in 1932.

Good progress was made with the sowing of turnips and swedes and much of the work was accomplished by the end of May; in several districts, however, the seeding of turnips was greatly retarded by the wet weather and soil conditions. Early sown swedes, although somewhat slow to come through the ground, generally showed an even braird at the beginning of June. In Roxburgh and Selkirk ground frosts, and in South-East Perth turnip fly, were the cause of some second sowings; in Berwick also "fly" was troublesome, but elsewhere the crop was free from insect pests. The reports received on sugar-beet state that at the beginning of June the crop showed an even and healthy braird. With farmers now taking more interest in the cultivation of the crop substantial increases in the acreage are expected this year in Moray, Fife, Berwick and Angus, particularly in North-East Fife.

Until the spell of cold weather in April and May prospects for all fruits appeared to be favourable, but at the end of May orchards had a less promising appearance. Some of the blossom was considerably damaged by strong winds or frosts and it is probable that the setting of the fruit will be affected in some districts. In Stirling it is estimated that the progress of fruit crops at the beginning of

June was a fortnight behind that of last year. In Lanark prospects were good for all fruits with the exception of strawberries, while in most other districts prospects of yields were fairly good.

Sheep stocks suffered severely from the wintry weather conditions that prevailed practically throughout the lambing season, and the final reports on lambing show that results have been most disappointing. In Caithness the fall of lambs was estimated to be above the average, but in most counties, and particularly in the north-east, in addition to reduced numbers of lambs, heavy losses among ewes and lambs occurred. In Lower Moray it was estimated that the crop of lambs was 50 per cent. below the normal, while a heavy death-rate in lambs was reported in Upper Moray, Banff, Kincardine, Kirkcudbright, Wigtown and parts of Aberdeen and North and East Perth. In Roxburgh and Selkirk lambing among hill flocks was very disappointing and losses were considerable. In North-East Aberdeen joint-ill, wool-ball and udder troubles were more prevalent than usual. In many districts ewes were thin and were not milking well, but with a few warmer days towards the end of May the condition of sheep stocks generally showed a slight improvement.

At the beginning of June there was a shortage of experienced female dairy workers in Dunbarton and Renfrew, while in North Argyll farm generals and dairymaids were scarce. Otherwise the supply of all classes of farm workers was sufficient for requirements, and in parts of Aberdeen many male workers failed to secure engagements at the Whitsunday hirings. In Roxburgh and Selkirk considerable numbers of unemployed men were absorbed in road-making.

SEED TESTING AND PLANT REGISTRATION STATION

Part II—REPORT

Virus Diseases. Building-up Healthy Stocks

At the beginning of 1929 the Department of Agriculture obtained a five years' grant for the purpose of conducting investigations into virus diseases of the potato with a view to the reduction of the number of seed potato stocks in Scotland infected with these degenerative diseases.

The grant has been utilised partly for the purpose of carrying out experiments in an insect-proof greenhouse, with corresponding observations in field plots, at East Craigs, and partly in providing assistance to farmers in the production, multiplication and maintenance of healthy stocks of potato varieties as foundation for larger prospective acreages of "stock seed."

An attempt had been made by the Department, by the introduction of a Stock Seed Scheme in 1922, to reduce the incidence of degenerative diseases in potato stocks in Scotland. This scheme,

which was based on the elimination of disease from stocks by persistent removal from year to year of all unhealthy plants, had only a limited measure of success. Although found to be effective when applied to the varieties Great Scot and King Edward VII, and to the disease of leaf roll in all varieties, the scheme did not prove successful in its application to other degenerative diseases in varieties other than the two cited.

The reasons for the failure of the scheme to increase the acreage of stock seed were :—

(1) Removal of unhealthy plants can never be absolute.

(2) Infection of healthy from unhealthy plants occurs before the removal of visibly diseased plants, the disease being transferred by greenfly.

(3) As a consequence the diseases reappear in the subsequent crop.

The only effective method of producing a stock entirely free from virus disease is to apply the principle of single plant selection of healthy plants and to propagate these in isolation.

In practice the application of this principle involves—

(1) The selection of a limited number of plants—preferably from a "stock seed" crop—which on careful examination by eye are found not to exhibit any symptoms of any virus disease.

(2) The harvesting and storing separately of each plant-unit selected and the subsequent propagation of the produce of these plant-units in conditions in which they are suitably isolated from each other and from sources of new infection ; conditions most generally available are those afforded in a turnip crop which is free from potato groundkeepers.

(3) The elimination during at least two seasons from the plant-units thus propagated of any unit which displays any symptom of virus disease.

(4) The assemblage, in the third or fourth year from the year of selection, of all units representative of the ideal healthy plant of the variety under process of selection, into a nucleus stock for multiplication at a sufficient distance from other potato crops to avoid risk of the stock becoming infected.

Ideally each unit which is finally admitted to the nucleus stock should be artificially tested to ensure that it is absolutely virus-free, but a general scheme of improvement of stocks on this basis is not practicable. The scheme applies to a variety *per se* and, although certain varieties are known to "carry," without display of

symptoms,* viruses potentially destructive to other varieties, the detection of the presence of these carried viruses is unnecessary. Moreover, except in the case of virus A, no evidence has been discovered of any means by which they can be transferred to other varieties except artificially. From the practical standpoint it is only necessary, therefore, to ensure by careful inspection that each individual unit finally admitted to the nucleus stock is visibly free from any symptom of virus infection at all stages of its growth, subject, however, to the proviso that selections from varieties which customarily display a mild evanescent mottling, the character of which is doubtful, should be artificially tested to prove whether or not the mottling is due to the mosaic virus.

Inception and Progress of the Scheme.—The first essay in the building-up of a selected stock from units was made in Aberdeenshire in 1926, the variety selected being Majestic. All the units, 29 in number, turned out to be not only apparently healthy, but also free from any carried virus when tested by core grafting in the greenhouse at East Craigs. In 1929 the units were bulked to form nucleus stock. The propagation of the stock was continued and in 1931 it occupied three and a half acres. Some of the stock was then distributed. In 1933 stock seed reports were granted in respect of about 50 acres of this stock, this figure including derivative stocks in the possession of other growers.

The initial success with this stock led to additional selections being made in 1928 from crops in the north of Scotland of the varieties Majestic, Golden Wonder, Catriona, Duke of York, Kerr's Pink. Arran Consul, Champion, Witchhill, Up-to-Date and May Queen. These units were tested in the greenhouse by grafting, and only the approved units were kept to form the built-up stocks. All these stocks in the hands of the original growers were of stock seed standard in 1933.

The official building-up scheme was inaugurated in the spring of 1929. The offer of assistance in the selection and examination of plants was, in the first instance, made to growers who had received "stock seed" reports and who could provide turnip crops free from potato groundkeepers. This latter condition is vital to success, because groundkeepers are liable to be affected with mosaic or leaf roll with the likelihood of the infection being transmitted to the units growing in the turnip crop. In 1930, however, the scheme was made available to all potato growers who considered they could fulfil the necessary conditions. The numbers of built-up stocks produced from the 1928, 1929 and 1930 selections were respectively 11, 25 and 32. The total number of stocks included in the scheme is now 147; this number includes 45 stocks which are due to be planted as bulked stocks in 1934, and 34 stocks

* 1. Paracrinkle (Salaman) by King Edward VII.
2. Up-to-Date Streak (Murphy)=Top Necrosis A (Quanjer).
3. Virus A (Murphy) by Irish Chieftain and possibly by Golden Wonder.

which require isolation in turnips during 1934 prior to approval for bulking in 1935.

The total number of growers engaged in the scheme is 65. The numbers of growers in the counties mainly concerned are—Perth (19), Aberdeen (14), Ross (8), Banff (6), Angus (5).

The table on the opposite page shows the progress of the scheme, especially with reference to its effect on the production of "stock seed."

Two old varieties, May Queen and Catriona, come into the stock seed list for the first time; Duke of York, Up-to-Date, Champion and Arran Chief return in improved condition after an absence of years; the acreages of stock seed of Majestic, Arran Consul and, to a lesser extent, Kerr's Pink, which have remained stationary or nearly so or have shown a decreasing tendency for a number of years, commence to increase markedly with an accompanying improvement in quality. The stock seed of Golden Wonder, Sharpe's Express, Arran Banner, Dunbar Cavalier, Arran Crest and Di Vernon includes a number of built-up stocks. Summarising these lists, with a knowledge of the condition of the stocks, it can be said that the most notable improvements have been effected in the case of the varieties Majestic, Up-to-Date, May Queen, Catriona, Duke of York, Arran Chief, Champion, Arran Banner and Dunbar Cavalier. The continuous increase in acreage shows that, when distributed, the stocks are capable of being maintained at a very high standard of health.

Simultaneously with the building-up work attention has been paid to the health of new varieties in order to ensure their development as virus-free stocks.

A feature of the scheme has been the advisory service conducted from East Craigs. In addition to the advice given in the field, growers are supplied with information as to the best methods of attending to their stocks. Wastage of stock by planting in unsuitable conditions is thus prevented so long as the stock is still on the original grower's farm.

Distribution of Selected Stocks.—Consideration of the manner in which these built-up stocks could be distributed with best advantage to the country has not been neglected. As soon as small stocks were available and had been included in the Department's stock seed list, recommendations were made to other growers to purchase one hundredweight of built-up stock of the variety in which they were interested. The one hundredweight lots were planted in long single drills in the middle of a clean turnip crop, and instructions were given for the correct cultivation of these lots so that the plants would be of normal growth. The policy of the single drill was adopted to facilitate removal of any doubtful or diseased plant along with its neighbours, thus to check disease at the point of outbreak and protect the rest of the stock from infection. The location of the potatoes in the middle of the turnips ensured sufficient lack of shelter to prevent infestation by greenfly.

ACREAGES OF STOCK SEED FOR 1931–1933, EXCEPTING KING EDWARD AND GREAT SCOT

Variety	1931 Derived from Built-up Stock	1931 Not derived from Built-up Stock	1932 Derived from Built-up Stock	1932 Not derived from Built-up Stock	1933 Derived from Built-up Stock	1933 Not derived from Built-up Stock	1933 Estimated acreage of Built-up Stocks not entered for inspection
Golden Wonder	7	65	10	$143\frac{1}{4}$	$27\frac{3}{4}$	91	1
Majestic	5	6	25	$7\frac{1}{2}$	62	$7\frac{3}{4}$	$\frac{1}{2}$
Kerr's Pink	$\frac{1}{2}$	$19\frac{1}{2}$	$3\frac{3}{5}$	$22\frac{1}{2}$	$13\frac{3}{4}$	26	1
Arran Banner	.	$3\frac{1}{3}$	$1\frac{2}{3}$	$15\frac{1}{3}$	$2\frac{3}{4}$	$23\frac{1}{4}$	..
Dunbar Cavalier	..	$1\frac{1}{8}$	..	$8\frac{5}{8}$	$\frac{1}{2}$	$9\frac{1}{2}$	..
Catriona	$1\frac{3}{8}$	..	$2\frac{3}{4}$	..	$6\frac{1}{2}$	..	..
Arran Scout	$\frac{1}{16}$	..	$\frac{1}{4}$	$2\frac{1}{4}$	1	$1\frac{1}{2}$	..
Arran Crest	..	$3\frac{2}{3}$	..	$2\frac{1}{4}$	2	..	..
Di Vernon	..	$1\frac{1}{12}$	$\frac{1}{2}$	$\frac{1}{8}$	$1\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{3}$
Arran Consul	$1\frac{1}{2}$	$1\frac{1}{2}$	$11\frac{1}{3}$	$4\frac{1}{3}$	$15\frac{3}{4}$	..	..
Witchhill	$\frac{1}{8}$	..	$\frac{1}{4}$	..	$1\frac{1}{10}$	..	..
Champion	..	..		..	$\frac{3}{4}$	..	$\frac{1}{10}$
Sharpe's Express	..	$7\frac{1}{4}$		$4\frac{3}{4}$	$\frac{3}{4}$	12	..
Arran Chief	..	..		$\frac{1}{4}$	$3\frac{3}{4}$	$1\frac{1}{2}$	..
Up-to-Date	$\frac{1}{8}$	..	1	..	4	..	..
Duke of York	$\frac{1}{2}$	..	1	$4\frac{5}{8}$	$2\frac{5}{8}$	..	$1\frac{1}{2}$
May Queen	..	..	$\frac{1}{4}$	..	$2\frac{1}{4}$	..	..
Arran Comrade	..	..	..	..	..	$\frac{1}{4}$	$\frac{1}{8}$
Ninetyfold	..	..	..	.	..	..	$\frac{3}{8}$
Rhoderick Dhu	..	..	..	.	..	..	$\frac{1}{8}$
	16	109	58	216	149	173	5
Older varieties in process of building-up—Arran Pilot, Ally, Eclipse, Epicure, British Queen and Doon Star	..	$24\frac{1}{2}$	..	20	..	$33\frac{7}{8}$	..
Newer varieties not being built-up—Doon Pearl, Arran Cairn. Ballydoon and Gladstone	..	$\frac{1}{4}$	..	5	..	$30\frac{11}{16}$	..
Older varieties not being built-up—Arran Luxury, Herald, Field Marshal, Abundance, Ben Lomond and Tinwald Perfection	..	$1\frac{1}{8}$	..	$3\frac{1}{4}$	..	$7\frac{7}{8}$	..
	16	135	58	245	149	246	5
	151		303		395		

In some cases built-up stocks were not available and ordinary stock seed was utilised instead. The extent to which this service was utilised is shown by the increase from 8 growers of 8 stocks in 1932 to 41 growers of 64 stocks in 1933. The principal counties concerned were—Perth (6), Angus (5), Ross (5), Kincardine (4), Berwick (4), and Lanark (4). The single hundredweight is not regarded as the ideal amount for distribution in all circumstances. Nevertheless, this quantity has been adopted as a convenient one in the case of primary stocks of new seedlings, being sufficient to plant a small area to which particular care can be applied.

The number of units finally approved for each variety is much less than the number selected, this indicating that primary infection has been contracted in the year of selection.

The following table shows (*a*) the number of stocks started, (*b*) the number of stocks discarded in (1) areas north of Aberdeen and (2) areas south of Aberdeen. The term "stock" here means either a stock in process of building-up or a stock bulked for the first time :—

	North		South	
	Stocks started	Stocks discarded	Stocks started	Stocks discarded
1928 . .	16	2	1	1
1929 . .	20	..	25	13
1930 . .	18	1	21	9
1931 . .	30	1	30	7
1932 . .	15	1	17	5
	99	5	94	35

Of the 35 stocks discarded in the south, 20 were rejected on account of the presence of groundkeepers or the proximity of diseased crops. The remaining 15, discarded as a result of infection received from the parent stock, are comparable with the 5 stocks discarded in the north. It is clear from these figures that the north of Scotland is particularly well adapted for the propagation of healthy stocks ; none of the 5 stocks discarded there was rejected because of groundkeepers or proximity to adjacent diseased crops. The ideal conditions for the production of seed potatoes are on farms where a long rotation is practised, so that potato crops do not follow closely on the same field. It must be emphasised, however, that ability and enthusiasm on the part of the grower are essential for the lasting success of the work.

Special Investigations and Tests.—Simultaneously with the work conducted in the field, critical investigations have been carried out in an insect-proof greenhouse. The facilities provided have been utilised to some extent to prove the health of selected units, but mainly (1) to provide solutions of particular problems and interpretations of phenomena arising out of experiences in the work of selection and in the work of general inspection of stocks,

especially with reference to stock seed, and (2) to confirm the findings of other workers on potato virus diseases.

The experiments—some 300 in number—have been carried out with a view to defining as strictly as possible the field symptoms which determine a plant as "diseased."

The following is a synopsis of the conclusions derived from these investigations and should be read in conjunction with the article by Dr Kenneth M. Smith in Volume XVI, No. 4, of this *Journal* (October 1933) :—

(1) Crinkle symptoms are caused either by the association of virus A (Murphy) (see 8 (*d*) below) and simple mosaic, as in Murphy's crinkle, or by virus Y (Smith).

(2) Severe mosaic symptoms in Scottish stocks of Majestic, Great Scot, Up-to-Date, Sharpe's Express and Arran Crest are probably due to virus Y.

The spread of the severe mosaic in Scotland, if of the Y type, is readily explicable as Y is borne by greenfly, but, if of crinkle (Murphy) type, can only be explained by supposing that virus A, which is also borne by greenfly, is transferred from plants affected with crinkle to plants already affected by simple mosaic.

(3) The symptoms of virus Y even in one variety vary from a severe mosaic to a mild mosaic and vice versa in successive years.

(4) Simple mosaic has been found to be synonymous with virus X (Smith).

(5) Mottling is generally the symptom of simple mosaic ; the mottling symptoms are frequently faint and evanescent. [As virus X is necrotic in its effect on the variety Epicure and on Tobacco, diagnosis of mottling is easy at a central institution.] Thirteen types of mottling in Majestic, 5 types in Kerr's Pink, 2 types in Arran Banner, 2 types in Arran Scout, as well as individual types in Arran Luxury, Catriona, Arran Pilot, Dunbar Cavalier, Doon Star, Arran Victory, Tinwald Perfection and Golden Wonder have been examined. The following types of mottling are not due to virus infection, but are climatic or environmental in origin :—(1) Pale mottling in some varieties due to very cold weather, (2) pale sulphury mottling due to a rush of growth, (3) pale mottling due to interference with the root system by damage or too shallow planting, (4) pinhead mottling due to ripening, (5) water mottle which is completely uniform.

(6) Virus Complexes. The addition (by grafting) of virus X to virus Y in the varieties President, Majestic and Up-to-Date does not cause any more intense symptoms than those due to virus Y alone.

(7) Abnormal types in Di Vernon are mostly due to infection with virus Y or virus X, but differences in form of haulm can be brought about by differences in date of planting and sprouting this variety.

(8) There are the following 5 types of streak :—

(*a*) Virus Y (Smith). The streak is of the leaf-drop type commencing near the bottom of plants and is always associated with crinkle or mosaic symptoms which are generally severe. The term "severe mosaic" is more apposite than streak. No "carriers" are known among British varieties.

(*b*) Top Necrosis A (Quanjer)—the streak carried by Up-to-Date and some other varieties. On intolerant varieties, when introduced by grafting, this virus causes necrosis which starts at the tips of shoots and is not accompanied by any marked mosaic symptoms. No insect vector is known. Some tubers of affected plants are killed by the virus ; some give rise to curly dwarf plants which die, others to plants showing symptoms of primary infection, while some frequently produce healthy plants.

(*c*) Virus X (Smith). This is the simple mosaic of Murphy which on most varieties shows as mild mottling, but which, when introduced to Epicure or Arran Crest by grafting or needle inoculation, causes top necrosis similar to that of (*b*). No insect vector is known, although the disease in the mottling form spreads readily in many districts.

(*d*) Virus A (Murphy). This virus, which is a constituent of Murphy's crinkle, is carried without symptoms by Irish Chieftain and possibly by Golden Wonder. On some varieties it causes a very faint mottling, but on Up-to-Date and British Queen it causes top necrosis similar to (*b*) and (*c*) when introduced by grafting or by greenfly.

(*e*) 539 Streak—an apparently physiological type which occurs on some varieties mainly towards maturity. This streak may be of the leaf-drop type ; the necroses are sometimes veinal, sometimes intercostal, and sometimes both. This streak is not necessarily associated with any form of mosaic. The symptoms cannot be transmitted by grafting or by insects ; this type of streak is therefore not a virus disease. The symptoms are not necessarily perpetuated by the produce of affected plants, and if they do occur it is towards maturity. It is the only streak actually evident in the field in Scotland without the accompaniment of severe mosaic symptoms.

Top necrosis, whether of the (*b*), (*c*), or (*d*) type (par. 8 above), has not been reported to occur naturally in the field except on one occasion. Top necrosis streak may therefore be regarded as an artificial symptom of disease. The 539 streak is probably the same as the condition originally described by Orton under the name of streak. Streak is therefore a misnomer for any virus disease. If streak symptoms occur along with severe mosaic symptoms as in virus Y infection, the description severe mosaic is more applicable than streak.

(9) Among plants derived from Golden Wonder exhibiting severe mosaic symptoms on one shoot only, one plant in every

20 showed severe mosaic. Similarly the produce of plants of Golden Wonder partially affected with severe mosaic, but on more than one shoot, showed one severe mosaic plant in every 6 plants. Severe mosaic symptoms appeared on single shoots of a stock of this variety grown in very sandy soil. The produce of such plants kept for study was healthy, showing that the mosaic symptoms were probably the result of a growth condition. The bright yellow mottling sometimes associated with blistering which is seen on Golden Wonder is not a symptom of mosaic, though the symptoms may be repeated to a limited extent in the progeny. In this variety severe mosaic symptoms frequently do not appear until the end of August and have been noted as being suppressed entirely for one season.

(10) Paracrinkle (Salaman) is a virus which seems to be universal in the carried state in King Edward stocks. A large number of sprout grafts confirmed this finding. No insect transmission of the disease to intolerant varieties could be obtained.

(11) Ninetyfold has been found to carry a virus similar to paracrinkle.

(12) An aberrant type of Arran Chief was found not to owe its appearance to virus infection.

(13) For the purpose of demonstrating to the inspectorial staff the typical appearance of the common virus diseases on all common varieties, these varieties were infected by means of sprout grafts with simple mosaic and crinkle in 1933, and additionally in 1934 with virus Y.

(14) New varieties have been tested for comparative resistance to virus diseases as undernoted:—

(*a*) Grafting tests, 1927, 1928, 1929.
(*b*) Field tests, 1926, 1931, 1932, 1933, 1934.
(*c*) Tests in insect-proof cages, 1930, 1932, 1933.

None of these methods has proved entirely satisfactory. The grafting method has been abandoned. The field tests are being continued, but would benefit from the assistance of an entomologist. Field tests suffer from the defect that under natural conditions it is impossible to ensure equal opportunity for infection. If the conditions are so suitable as to ensure the infestation of all varieties with greenfly, then all varieties become affected with leaf roll. In these tests severe mosaic has been freely transmitted.

Review of the Building-up Scheme.—The original object of the building-up scheme was to provide stocks of stock seed standard of all common varieties (excepting Great Scot and King Edward) which would be more reliable than ordinary stock seed. After the bulking of the units approved during their isolation in turnips it was expected that the bulked produce would become eligible for the stock seed certificate. Moreover, in view of the anticipated freedom from sources of infection within the stock, it was

considered that built-up stock could be multiplied to any extent without becoming affected with a virus disease as long as it was sufficiently well isolated from other potatoes. The scheme has advanced far enough to show that even when the maximum of attention is given to detail in protection absolute perfection cannot be realised. Undetected sources of infection frequently occur within or in proximity to the selected stocks.

Extraneous sources of infection include unhealthy tubers carried to the field by rooks or introduced in farmyard manure, persistent groundkeepers from a previous crop, cottage gardens containing unhealthy crop, and winged greenfly carried on the wind from a distant potato crop containing unhealthy plants. The last-named is probably the source of infection in 1933 with leaf roll of 4 stocks which in previous years had been free from virus disease.

Internal Infection.—(1) The symptoms of simple mosaic are frequently masked and may remain undetected in a unit which is the subject of inspection for a very brief period of time twice during each of two seasons.

(2) On rare occasions the symptoms of severe mosaic remain unexposed for a year or two in a unit after it has been infected and then appear more or less suddenly, *e.g.* in Golden Wonder.

(3) Mosaic symptoms in Golden Wonder sometimes appear towards the end of the period of growth after final inspections have been made. These may remain undetected.

No credence is given to the theory that virus disease symptoms may appear spontaneously in a plant where previously the virus existed in a carried state.

The interpretation of the various types of mild mottling is an important matter because of the perplexities constantly presented in the work of inspection for the purpose of health grading. There is reason to believe that most of the mild mottling observed during the growing season is the result of virus infection, as the results of critical tests have clearly shown. Having regard to the fact that mottling may vary in severity even in different portions of the same stock, it is an insurance against error to maintain stocks quite free from it.

Foundation Stock.—The foregoing review points clearly to the need for perpetuating unimpaired the approved built-up stocks. In order to encourage this practice the Department have instituted a special stock seed certificate which applies to stocks of not more than one acre, in which every plant has been examined twice and found to represent the best type of plant of the variety under consideration. The object of this " Special Stock Seed " scheme is to provide stock, not for general planting, but for use only as a nursery stock for the farmer's own planting, or for distribution to specialist seed growers on the basis that crops certified as special stock seed are suitable for extensive planting for the propagation of stock seed. The intention is to encourage a regularly practised system

of seed potato production, in which special stock seed will be used for the production of stock seed, which in turn will be used for planting in the intensive potato growing districts primarily for the production of ware crops with a seed portion of the grade known as T.S.H. or N.T.H. which is the grade in most demand in England at present.

In 1933, 32 built-up stocks were awarded the special stock seed report. These stocks include all the popular varieties most difficult to improve.

SCIENCE AND PRACTICE

The following extracts and summaries are supplied by members of the staffs of Scottish agricultural colleges and scientific institutions or are taken from recent bulletins of the International Institute of Agriculture. Full references to the original publications may be obtained on application to the Secretary, Department of Agriculture, York Buildings, Edinburgh.

CROPS AND SEEDS

Establishment and Management of Permanent Pastures on the Light Lands of the Canterbury Plains (New Zealand). *A. H. Flay. New Zealand Journal of Agriculture, Volume* 47, *No.* 2, August 1933.—It has been generally believed that perennial rye-grass will not remain permanent on the light lands of the Canterbury Plains, but experiments conducted by the Department of Agriculture and by farmers showed that true perennial rye-grass is permanent when properly established, manured and grazed. With dry weather permanent rye-grass shoots to seed, and its dry-weather production and carrying capacity therefore are low, but it responds fairly quickly to autumn and winter rains.

The carrying capacity of perennial rye-grass is greater than that of cocksfoot on medium and better-class light lands. Cocksfoot has one advantage over perennial rye-grass; it withstands close grub attack reasonably well. The best grazing management of cocksfoot is somewhat different from that of perennial rye-grass. The intervals between the grazing should be longer, and the grazing should not be so close. Periodically the pasture should be given fairly lengthy spells to allow of complete renewal of the crown of the plant.

Red clover is one of the highest summer producing herbage plants. The economic value of lucerne on these dry light lands has not yet been established. While red clover is not a prolific grower in dry weather, it produces a great volume of feed during the late spring. The best yields of leafage are obtained by controlled grazing with long intervals between the grazings.

Potato Trends. *W. Stuart. American Potato Journal, Volume* 10, *No.* 3, *March* 1933.—This paper deals with trends in the United States of America. In harvesting crops of potatoes progress is being made by the use of suitable machinery to lessen mechanical injury of the tubers. Efforts are being made in two regions to stabilise production, and attempts are also being made to restrict the flow of potatoes to marketing centres so as to avoid an over- or an under-supplied market. In these two centres high standards of grading are maintained.

A recent development in the marketing of potatoes is that of putting them up in small packages suitable for the consumer's needs. The package in most favour is the 15-pound sack, and only first-class tubers are packed in this manner. There is an increasing tendency on the part of firms marketing potatoes in these small sacks to wash or brush thoroughly the tubers before packing them. Machines for both washing and brushing are now available. The writer of the paper prefers the brush machine, which removes the soil and polishes the skin of the potato in one operation. When potatoes are cleaned in this manner, it is much easier to detect and remove defective tubers. Machines are now available that will brush and polish 1000 bushels of potatoes per day.

Experiments in Combating Finger-and-Toe Disease (*Plasmodiophora brassicae*). *N. J. Nielsen. Tidsskrift for Planteavl,* 39 *Binds,* 3 *Haefte* 1933. *Author's English Summary.*—Experiments in combating finger-and-toe disease were made at the Danish Experiment Station, Studsgaard, Jutland, 1908-18. The experiments indicate that two factors are of importance in attacking this disease; lime application up to a suitable soil reaction, and a sufficient lapse of time between crops of crucifers. If one of these factors is neglected the other becomes doubly important.

The lime experiments were made on slightly acid, loamy soil. Results show increasing yield for increasing lime applications up to 18,000 kg. pr. ha. (approx. 7 tons per acre). This quantity, which has given the soil a slightly basic reaction, has not as yet shown any ill effects on other crops in the rotation.

It seems to make little difference whether the lime is applied as burned lime or as carbonate, all at once or in several doses, in the autumn or in the spring.

If a crop of crucifers is grown in a field every six or eight years, it seems possible to avoid severe attacks of the disease. Growing crucifers every fourth year only, *i.e.* with three intervening non-cruciferous crops, seems as a rule not sufficient to check the disease.

In the experiments both infected and non-infected manure were tested. The swedes were grown in rotation every fourth year in soil, which, at the beginning of the experiment, was severely infected. The other experiments have shown that under these conditions ample opportunity is afforded for maintaining the infection unabated, and it is then quite understandable that applications of infected manure did not influence the attack.

There seems to be a possibility that infection in the soil is maintained through cruciferous weeds, but there appears to be no danger of spreading the disease through the seed.

SOILS

The Question of the Nitrogenous Manuring of Light Acid Soils. *Kraunich. Zeit. Pf. Dung u. Bk.*, 1934, *B.*, 13.2.49.—Experiments with sulphate of ammonia and nitrate of soda as compared with no nitrogen were conducted on limed and unlimed areas—the crops grown being rye, oats, barley, and potatoes. Sulphate of ammonia in the absence of lime proved unsatisfactory for barley, but gave with the other crops increased yields over the "no nitrogen" treatments. Nitrate of soda was found generally to be superior to sulphate of ammonia, especially on the unlimed areas.

On the Internal and External Factors governing the Utilisation of Ammonia Nitrogen by Plants. *Prjanischnikov. Part 2. Zeit. Pf. Dung. u. Bk.*, 1934, *A. 33*, 3/4, 134.—A description is given of a series of culture experiments with seedlings of peas, lupins, turnips and oats, and varying amounts of ammonium nitrate. With etiolated plants the lower the carbohydrate reserve the smaller are the amounts of ammonia nitrogen utilised for the formation of organic nitrogen compounds and the less rapidly is ammonia assimilated. The effects on the seedlings of varying the concentration of ammonium nitrate employed, the duration of the experiment, the acidity of the solution, and other factors are pointed out.

On the Chloride Content of Soils and the Effect on Potatoes of Chlorides in Potash Manures. *Nemec. Zeit. Pf. Dung. u. Bk.*, 1934, *A. 33*, 5/6, 346.—The results are given of a series of experiments laid down to study the effect of various potash manures on the yield and starch content of potato tubers; account is taken of the chloride contents of the soils. From the experiments conducted it appears that the various potash manures exert much the same effect on yield, but potash manures containing chlorides—kainit, potash salts, and muriate of potash—bring about a reduction in the starch content of tubers, and in this respect differ from sulphate of potash.

Sand and Water Culture Experiments on the Effect of the Zinc and of the Cadmium Ions. *Scharrer and Schropp. Zeit. Pf. Dung. u. Bk.*, 1934, *A. 34*, 1/2, 14.—Results are given (1) of sand culture experiments with zinc on wheat, rye, barley, oats, maize and peas, (2) of water culture experiments with zinc and with cadmium on maize, and (3) of sand culture experiments with cadmium on wheat, rye, barley, oats and maize. For equal concentrations cadmium appears to be distinctly more poisonous than zinc.

Over-manuring and Depression of Yield. *Mitscherlich and Kuhnke. Zeit. Pf. Dung. u. Bodenk*, 1934, *B. 13*, 4, 151.—With cereals there is a danger of lodging if too much nitrogen is present; there is much less risk of overdosing roots with nitrogen. To study the effect of large dressings of potash and phosphoric acid, experiments have been conducted on barley and on a following crop of potatoes with varying dressings of potash and phosphoric acid. With barley a definite depression in yield was observed only with the highest dressing of potash salts, viz. 52 cwt. per acre, 40 per cent. salts. No depression in the yield of barley was observed on the addition of quantities up to approximately 44 cwt. per acre sulphate of potash and 52 cwt. per acre superphosphate respectively. With potatoes, quantities of about 13 cwt. per acre, 40 per cent. potash salts, and 44 cwt. per acre sulphate of potash depressed the yield; the starch content of the potatoes, however, was reduced by relatively small quantities of potash salts and by quantities greater than 8 cwt. per acre sulphate of potash. Quantities of superphosphate up to about 52 cwt. per acre caused no depression either in yield or in starch content of potatoes.

Effects of Applications of Nitrate of Soda upon the Yields of Timothy Hay and Seed. *Evans. Journ. Amer. Soc. Agron*, 1934, *26*, 3, 235.—The effects of nitrate of soda on the

yields of timothy hay and seed were found to vary with the rainfall; the greatest yield of hay was obtained in the season with the greatest spring rainfall, and the yields of seed were greater when the rainfall was slightly below normal. Nitrate of soda was found to increase the yields both of hay and seed. The results show that generally there was no tendency for the timothy plants to make a vigorous vegetative growth at the expense of seed production; for each rate of application of nitrate of soda the resulting increase in the yield of seed was greater than the corresponding increase in the yield of hay.

The Effect of Potash Manuring as observed on the Lauchstädt Experimental Plots. *Selke. Die Ernahrung der Pflanze*, 1934, *30*, 11/12.—Results are given illustrating the effect of potash manuring, with and without farmyard manure, on crops of sugar-beet, spring barley, potatoes and wheat.

DAIRYING

Influence of Mastitis on Curd Tension of Milk. *Hansen. Theophilus, Atkison and Gildow* (1934). *J. Dairy Science*, 17 (3) 257.—The milk of some cows coagulates in the stomach with the production of a soft incoherent curd, while that of other cows produces a firm hard curd under similar conditions. Soft curd milk is stated to be easily digested and to be specially adapted for infant feeding. It is known that the incidence of certain udder infections such as mastitis affects the coagulability of the milk by rennet, and the authors have sought to determine whether mastitis might not be responsible for milk which judged by the Hill (Curd Tension) test might be classed as soft curded. They find that mastitis caused by a streptococcal infection invariably lowers the curd tension of the milk to such an extent that the milk would be classed as a soft curd milk, but that mastitis caused by a staphylococcal infection had no appreciable influence on the curd tension. Hence special precautions should be taken to see that a soft curd milk is the product of a healthy udder, and does not owe its essential characteristic to the incidence of streptococcal mastitis.

ANIMAL BREEDING

Cattle

Fat Percentage of Milk affected by Feeding Fats. *N. N. Allen.* 1934. *Jour. Dairy Sci.*, *17*, 379-395.—In this experiment the fat content of the milk of dairy cows was markedly increased when the fat content of the ration was increased by the feeding of butter-fat, lard, tallow, linseed oil, cotton seed oil, corn oil, peanut oil, soya bean oil, or cocoanut oil.

This increase was secured regardless of the breed of the cows, stage of lactation, level of production, or season of the year. It was due primarily to increased butter-fat production, since the milk yield was influenced only to a slight extent except in the case of cocoanut oil, which appeared to cause a depression of milk yield when fed in large amounts. A period of 12 to 24 hours after the fat was fed elapsed before its influence became observable in the milk. Hitherto, the general belief has been that the fat composition of the milk cannot be greatly altered by feeding, and that it is primarily a genetic problem. This paper reopens the question.

Efficiency Variations in Steers. *L. M. Winters and H. M'Mahon.* 1933. *University of Minnesota Tech. Bull.*, 94.—The fundamental purpose of live stock improvement is to develop strains of live stock that are more efficient in converting foodstuffs into products more useful to man. The objects of three years' experimental feeding trials presented in this paper were as follows:

(1) To determine the variations in efficiency of food utilisation by steers of a given age, and whether these were of sufficient magnitude to be of economic importance to the producer.

(2) To develop methods of feeding and handling that would make accurate feed records possible.

(3) To discover characteristics that would indicate an efficient animal.

(4) To formulate a record of performance programme that would aid in the development of more economical strains of cattle.

In 1930, 18 grade Shorthorn steers were purchased averaging about 750 lb. All the steers were treated in the same manner. There was a total difference of 131 lb. in total gains between the two extreme steers. The amount of food per 1 lb. of live weight gain varied from 10·1 lb. to 13·1 lb., the food cost per 100 lb. gain varying from 10-12½ dollars.

The second experiment, a year later, dealt with Hereford steer calves of a lighter weight than those used in the first test. Here the feed per lb. of live weight gain varied from 6·7 lb. to 8·6 lb.

The third test in 1932 was also with Hereford steers similar to the second lot, and here the feed per lb. of live weight gain varied from 6·2 to 9·0 lb.

At the same time as these experiments were in progress group-fed steers were being tested in a like manner as a group, but not individually, in order to find out the effect of individual feeding. In one test the steers fed individually gained only 2 lb. per day as contrasted with those fed in a group which gained 2·3 lb. It also cost more to feed the individually fed steers than those in the "feed lots."

There is a great deal of other interesting information in this paper.

Grading Meat. *J. Hammond and G. N. Murray.* 1934. *Jour. Agr. Sci., 24,* 233-249. —Dr Hammond has for many years studied the carcases at the Smithfield Show, and has examined the economic and scientific problems involved. In this paper it is pointed out that small joints in carcases can be obtained not only by using smaller breeds killed at the same age, but also, probably more profitably, by killing the same breed at an earlier age. From the figures given, many examples are shown where the value in price per stone of carcase decreases with increasing weight to such an extent that the profit obtained would be greatly decreased if the value of the maintenance food during the time taken to attain the increased weight is taken into consideration.

There are interesting tables and diagrams which illustrate these points for sheep, pigs and cattle in regard to the different breeds of each.

From the genetic point of view, since the weight-price curves for carcases from the different breeds and types of sheep and pigs do not run parallel, owing to the different weights at which the different breeds mature, it would appear better to institute weight classes in carcase competitions at shows rather than age classifications. The writers add that, since with beef there appears to be very little differences in price due to sex, it would seem that sex differences in classes might be eliminated, and in their place classes might be instituted for animals of different weights. They point out that such a system has been working satisfactorily with pork and bacon for a number of years and might, with advantage, be adopted also for mutton and beef.

In the lower weight classes the prevailing fault is a low proportion of muscle to bone, while in the higher weight classes the prevailing fault is a high proportion of fat to muscle. Thus the authors state it would appear that, for comparative breeds, the decrease in price with increase is due to two factors: (1) to increase in the size of the joints, and (2) to increase in the proportion of fat with increasing weight of the carcase within the breed.

Pigs

Defective Skulls of Pigs. *E. H. Hughes and H. Hart.* 1934. *Jour. Hered, 25,* 111-115.—A large proportion of young pigs born are deformed. That more attention is not drawn to this subject is probably due to the large size of the litter of the sow. One or two more or less does not as a rule make a great deal of difference. This report comes from California, and deals with Poland China pigs. The abnormality appears to be due to the lack of fusion of certain bones in the skulls, particularly those associated with the parietal. The openings have varied in length from 6 to 16 millimetres and in width laterally from 4 to 6 millimetres. The condition is usually accompanied by a protuberance located in the centre of the forehead. The projecting part does not seem to be covered by a true outer epidermis. The affected pigs in this herd were as large and as strong as their litter mates. Few of them have been brought up to 200 lb. live weight, the majority dying soon after birth. The condition has more recently been observed in the Poland China herd of the University of California. The condition is probably widespread in occurrence, and there is evidence that it has existed in other parts of the United States. That it is hereditary there can be no doubt. While the evidence is not conclusive, it would appear as though the condition described was due to a heterozygous pair of factors, the homozygous condition leading to death in utero.

Poultry

Mortality in the Egg. *F. B. Hutt and A. M. Pilkey.* 1934. *Poultry Science, 13,* 1-13. —Malpositions of the embryos of chickens in eggs which were late hatched were examineds Six different malpositions were discovered and these are detailed. The question wa. reviewed in relation to the position of the egg in the incubator. The results suggest that there are stages of incubation when it is advantageous to have the eggs with the large ends up, and others when the horizontal position is preferable. Incubating with the large end up until the twelfth or fourteenth day should reduce the frequency of one of the malpositions. Thereafter the advantage would appear to lie with the horizontal eggs if three other malpositions are to be kept at a minimum. It would mean that the eggs would be turned in one plane for the first two weeks of incubation and in another during the last four days of turning. The writers state that it is probable that the lower embryonic mortality observed by several investigators when eggs were turned four to six times daily, compared with that resulting when eggs were turned only twice, may be to some extent associated with the lowered frequency of malpositions.

There are a lot of other interesting points raised in this paper.

Egg Production—Selection by Ancestors' Yields. *M. A. Jull.* 1934. *Journ. Hered.*, 25, 61-64.—The writer is of opinion that the actual number of eggs laid by a hen and by her ancestors, as well as by the maternal ancestors of her sire, has relatively little significance in breeding for egg production. He demonstrates this by the results secured from various matings of sires and dams selected on the basis of the dam having laid a minimum of 200 eggs during the first laying year. These results came from matings of Rhode Island Red birds and the production of 701 daughters sired by 15 different cocks and out of 121 hens. These daughters were produced during three years—1928, 1929, and 1930. The hatching season each year occurred from March 17th to the first week in May. Housing conditions, the rations fed and methods of feeding were the same. Artificial light was used during the winter months.

The 121 dams were selected on the basis of having laid a minimum of 200 eggs each. Four tables give the statistical results. From these it is apparent that in this selected group there is no significant relationship between the egg production of the dams and that of their daughters. The daughters of dams whose egg production ranged from 211-220 eggs laid better than the daughters of any other class of dams. In other words a dam that laid 270 eggs would, on the average, produce daughters that would lay no better than a dam which laid 220 eggs.

As regards the sires, the main egg production of the sires' daughters does not appear in significant relation to the egg production of his dam nor of either of his grand-dams.

The author is of the opinion that when a minimum first year record of 200 eggs is used as the basis of selective breeding stock, the actual number of eggs laid by any bird does not indicate the breeding ability of that bird, nor does the egg production of the sire's dam serve as an index of the breeding ability of the sire. Furthermore, the egg production of the three nearest female ancestors has been shown to have no significant relationship to the egg production of the progeny.

The author concludes by stating that these observations do not discount the value of pedigree breeding which involves recording the ancestry of every bird in the flock, because it is only when pedigree breeding is carried on that progeny testing can be employed in order to achieve progress through the results secured from given matings.

General

Inherited Lethal Characters in Domestic Animals. *F. B. Hutt.* 1934. *Cornell Veterinarian 24*, 1-25.—This is a summary of those known inherited characters in farm live stock which lead to the death of the embryo or the production of a dead fœtus. It is useful that these should have been gathered together into the space of a few pages. One of the interesting cases which has not previously been reported in these columns is that of a sex-linked lethal in a strain of horses in Russia where a significant deviation from the usual equality of the sexes was found, there being only 55 males to 90 females. Dr Kislowsky was able to show that in the lines of descent believed to carry the lethal gene the reproductive efficiency was only 68 per cent., whereas in the lines not carrying the gene it was 73 per cent.

ANIMAL NUTRITION

Effect of Silage made with Addition of Acid on Digestibility, Nitrogen, Calcium, and Phosphorus Balances in Cattle, Sheep, and Pigs. *F. Gramatzki. Ztschr. f. Tierzuchtung u. Züchtungsbiol.*, 1933, *28*, 433-450. (*Animal Breeding Inst., Albertus Univ., Königsberg i. Pr.*).—Metabolism experiments, 15-day periods, were made on an ox and a wether fed only clover silage with mineral acids (hydrochloric and phosphoric) or clover hay, and on two pigs fed steamed potato silage, with and without the addition of mineral acids. In the ruminants, utilisation of nitrogen was reduced by addition of acids, and the phosphorus and, to a less extent, the calcium balance reduced. In the pigs the results were similar, the P and Ca balances being most affected when free mineral acid was present in the silage. These results refer to the feeding of silage alone. Such silage, mixed with other foodstuffs, would probably give better results.

The Palatability of the Self-establishing Species contributing to Different Types of Grassland. *W. E. J. Milton. Empire J. Exp. Agric.*, 1933, *1*, 347-360. (*Welsh Plant Breeding Stat., Aberystwyth.*)—The relative palatabilities of miscellaneous herbs, grasses and clovers on different types of grazing land were investigated. These were found to be approximately the same for each type of grazing land except that grasses showed distinct differences due to stage and type of growth and the presence of burn. Burn and winter greenness were definite factors in influencing the choice of the grazing animal between miscellaneous herbs and grasses on lowland fields and between the individual species on hill pastures.

The relative productivity and amount eaten of the miscellaneous plants are discussed, and figures for the mineral and dry matter contents are given.

Feeding Potato Flakes to Horses, Cattle, Sheep and Poultry. *H. Lüthge. Süddeutsch. landwirtsch. Tierzucht*, 1933, 331-332. (*Halle a/S.*)—A suitable ration, containing potato flakes, for horses is: potato flakes 30, oats 60, soya or bean meal 5, molassed feed 5 per cent. Since potato flakes contain less protein than oats, a protein supplement must be given. Potato flakes may also be fed to cows with high milk production; they are well suited for dry cows and fattening cattle in quantities of 2-3 kg. per head per day. Young lambs readily eat potato flakes, and suckling ewes may be given 250 g. daily. Dogs will take 150 g. daily and for laying hens ½ to ⅓ of the mixed ration may be potato flakes.

A Note on the Uses of Pomace. *B. T. P. Barker. J. Minist. Agric. Engl.*, 1933, *40*, 710-715. (*Agric. Res. Stat., Long Ashton, Bristol.*)—Pomace is the residue from the manufacture of cider. In the fresh state it has a composition somewhat similar to mangolds, except that it contains double the percentage of carbohydrate. With care the wet material can be fed to cows, although there is risk of scouring and taint if it is not fed fresh or in limited quantity. Dried pomace is a low grade concentrate, but its value has not been accurately determined by controlled feeding tests.

Effect of Oats on Production in Cows. *Z. Kolanowski. Roczniki Nauk Rolniczych i Lesnych*, 1933, *30*, 273-280. (*Inst. Zootech., Univ. Poznan.*)—In an experiment on 7 cows a mixed ration of feeding beet, barley straw and rape cake, with some barley and a small supplement of soya bean meal, was fed in the first and fourth periods. In the second and third periods, the barley and soya bean meal were replaced by oats and potato starch, the digestible protein and starch value being unaltered. The introduction of oats into the ration gave an increase of 5·8 per cent. in milk yield with a fall of 5·5 per cent. in butter-fat.

Milk Yield and Iodine Content of Milk of Cows on Iodine Manured Pasture. *K. Scharrer, W. Schropp, and J. Schwaibold. Biedermanns Zentralbl. B., Tierernährung*, 1933, *5*, 676-700. (*Agric. Cehm. Inst., Weihenstephan, Tech. Coll., Munich.*)—Cows pastured on iodine manured fields, the grass of which showed an increased iodine content, had a higher milk yield, of higher iodine value, and a prolonged lactation period. Favourable effects on the œstrous cycle were also noted.

Value of Skim Milk for Pigs on Pasture. *V. A. Freeman. Michigan State Coll. Agric. Exp. Stat. Quart. Bull*, 1933, *16*, 107-109. (*East Lansing, Michigan.*)—Three groups of 14 pigs on pasture were fed corn and minerals and the following amounts of skim milk daily per pig: Group (1), 3 lb.; group (2), 6 lb.; group (3), unlimited amount. The greater the quantity of milk consumed the more rapid was the increase in weight, but the less economical was the gain or the return for the milk fed.

Fish Meal and Meat Meal in Pig Fattening. *J. C. De Ruyter De Wildt. Vereen. Exploit. Proefzuivelboerderij, Hoorn, Ann. Rep.*, 1932 (1933), 53-99.—The average composition of 72 samples of meat meal and fish meal is tabulated, and 3 experiments recorded on 65 fattening pigs, comparing white fish meal with "Carnarina," an American meat meal. The groups on the latter showed 6 per cent. superiority in growth rate; on the former a somewhat better distribution of carcase flesh and fat was found. The iodine value of fat of fish-fed animals was slightly higher.

Potato Feeding. *Dr Stahl. Ztschr. f. Schweinezucht.* 1933, *40*, 681-684. (*Ruhlsdorf, Kr. Teltow.*)—An account is given of the Lehmann system of potato feeding for pigs of all ages, including breeding stock. The system consists of feeding 700 g. cereal meals plus 300 g. fish or meat meal per pig per day, plus steamed potatoes to appetite.

Potatoes in the Ration for Laying Hens. *A. Wehner. Arch. f. Geflügelk*, 1933, *7*, 289-295. (*Poultry Breeding Stat., Erlangen.*)—Experiments on 2 groups each of 15 Leghorn hens, of which one received a good laying ration and the other a protein concentrate and steamed potatoes, showed that potatoes may replace the more costly cereal starch without reducing egg yield or weight of the hens. Potatoes are, however, not recommended for the production of eggs for hatching, since hatchability seemed to be lower where large quantities of potatoes were fed.

Effect of Cotton Seed Diet on the Composition of the Egg. *V. G. Heller, V. Searcy, and R. B. Thompson. Proc. Oklahoma Acad. Sci.*, 1932, *12*, 45-52.—On storage, H_2O passes from white to yolk. Eggs from gossypol-fed hens have viscosity and coefficient of spread, but not an olive colour, similar to those of eggs of hens fed on cotton seed meal. For the latter, pH, H_2O, fat and protein contents, N distribution, and I value of yolk fat were normal.

STATISTICS

PRICES OF AGRICULTURAL PRODUCE, FEEDING STUFFS, AND FERTILISERS IN MARCH, APRIL, AND MAY 1934.

Live Stock: Monthly Averages of Prices at certain representative Scottish Markets.

(Compiled from Returns received from the Department's Market Reporters)

Description	March			April			May		
	1st Quality	2nd Quality	3rd Quality	1st Quality	2nd Quality	3rd Quality	1st Quality	2nd Quality	3rd Quality
FAT STOCK:—									
*Cattle—	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.
Aberdeen-Angus ..	45 6	41 0	40 0	45 10	41 6	40 0	46 7	42 1	40 5
Cross-bred (Shorthorn)	42 4	38 8	31 7	42 5	38 7	31 10	43 1	39 0	31 10
Galloway	40 11	38 7	..	41 2	38 9	..	41 11	38 10	..
Ayrshire	39 1	35 3	29 1	39 8	36 5	31 8	39 2	34 8	28 9
Blue Grey	47 5	43 5	40 0	46 2	43 2	40 0	47 10	43 10	40 5
Highland	41 6	37 6	..	..	..	..	45 8	42 2	40 0
	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.
†Veal Calves	14	4	..	12	4	..	12¾	4	..
†Sheep—	Hoggs under 60 lb. per lb. d.	60 lb. and upw'd. per lb. d.	Ewes per lb. d.	Hoggs under 60 lb. per lb. d.	60 lb. and upw'd. per lb. d.	Ewes per lb. d.	Hoggs under 60 lb. per lb. d.	60 lb. and upw'd. per lb. d.	Ewes per lb. d.
Cheviot . .	10½	9½	7½	11¾	10¾	8½	13¼	12½	8
Half-bred . .	9¾	9	7¼	11	10	8	12¼	11½	7¾
Blackface .. .	10½	9¾	7½	11½	10½	8¼	13½	12¾	8½
Greyface .. .	10¼	9½	7½	11½	10¼	8	12¾	11¾	8
Down Cross	10	9½	7½	11¼	10½	7½	13	12¼	7
†Pigs—	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.	per stone s. d.
Bacon Pigs	9 7	8 9	..	9 5	8 9	..	9 2	8 4	..
Porkers	10 6	9 8	..	10 3	9 6	..	9 10	9 2	..

* Live weight. † Estimated dressed carcase weight.

LIVE STOCK : Monthly Averages of Prices (per head) at certain representative Scottish Markets—(*continued*).

DESCRIPTION	MARCH						APRIL						MAY					
	1st Quality		2nd Quality		3rd Quality		1st Quality		2nd Quality		3rd Quality		1st Quality		2nd Quality		3rd Quality	
STORE STOCK :—																		
CATTLE—																		
Aberdeen-Angus :	£	s.	£	s.	£	s.	£	s.	£	s.	£	s.	£	s.	£	s.	£	s.
Yearlings	14	10	11	9	8	10	14	8	11	9	9	5	13	18	10	18	8	8
Two-year-olds ..	18	3	15	2	11	13	17	12	14	16	11	9	18	0	14	13	11	0
Cross-bred (Shorthorn)																		
Yearlings	13	1	10	7	8	0	13	7	10	14	8	3	13	10	10	3	7	11
Two-year-olds ..	17	0	13	14	10	3	16	19	13	18	10	19	17	5	13	10	10	1
Galloway :																		
Yearlings	12	10	9	15	..		12	19	10	8	..		13	0	10	1	..	
Two-year-olds ..	..		13	15	..		20	10	16	0	..		..		16	8	..	
Ayrshire :																		
Yearlings	..		..		..		11	1	8	18	7	10	10	19	9	5	7	10
Two-year-olds ..	..		..		..		15	13	13	0	10	0	13	5	11	0	9	0
Blue Grey :																		
Yearlings	12	0	10	10	..		14	0	..		..		13	10	..		..	
Two-year-olds ..	..		..		..		21	0	16	10	..		18	0	15	8	..	
Highland :																		
Yearlings	..		..		..		..		..		..		..		..		..	
Two-year-olds ..	..		..		..		..		..		..		..		..		..	
Three-year-olds ..	..		..		..		..		..		..		..		..		..	
DAIRY COWS—																		
Ayrshire :																		
In milk	23	11	17	5	13	8	23	13	17	11	13	14	23	7	17	12	13	10
Calvers	24	2	18	4	14	2	24	9	19	2	14	12	24	14	18	13	14	10
Shorthorn Cross :																		
In milk	24	6	17	13	16	10	24	15	18	6	16	4	24	10	17	12	15	12
Calvers	23	6	17	1	14	16	23	9	17	2	16	3	23	9	16	12	13	14
SHEEP—	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
Cheviot Hoggs ...	32	7	29	2	..		38	5	29	1	..		38	2	27	2	..	
Half-bred Hoggs ..	42	4	30	0	..		45	7	30	7	..		44	4	33	5	..	
Blackface Hoggs ..	26	2	18	8	..		26	11	21	8	..		29	6	21	10	..	
Greyface Hoggs ..	34	9	28	8	21	6	37	8	29	7	25	0	39	3	31	1	26	9
Down Cross Hoggs	..		..		..		..		..		..		..		..		..	
PIGS—																		
(6 to 10 weeks old)	35	8	22	6	..		34	7	21	9	..		37	2	24	7	..	

DEAD MEAT: Monthly Average Prices at Dundee, Edinburgh, and Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

Description	Quality	March Dundee	March Edinburgh	March Glasgow	April Dundee	April Edinburgh	April Glasgow	May Dundee	May Edinburgh	May Glasgow
BEEF:—		per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.
Home-fed—										
Bullock or Heifer ..	1	7¼	6⅞	8¼	6⅞	7⅛	8⅛	6⅞	7⅛	8
	2	6¾	..	7½	6⅝	..	7½	6½	..	7¼
Bull	1	5½	5⅛	6	5⅛	5⅛	6	5⅛	5¼	5¾
	2	4¾	..	5½	4⅝	..	5½	4⅝	..	5⅜
Cow	1	4¾	4⅞	5½	5	4⅞	5½	4⅞	5	5¼
	2	4⅜	..	4⅝	4½	..	4½	4½	..	4¼
Irish—										
Bullock or Heifer ..	1	..	..	7½	..	..	7½	..	..	7¼
	2	..	..	6½	..	..	6½	..	..	6¼
Argentine Frozen—										
Hind Quarters ..	1	4⅛	4¼	..	4½	4¼	..	4⅝	4¼	..
	2	..	3⅝	..	..	3⅝	..	..	3⅜	..
Fore ,, ..	1	3½	3¼	..	3½	3½	..	3½	3¼	..
	2	..	2½	..	..	2⅞	..	..	2¾	..
Argentine Chilled—										
Hind Quarters ..	1	6	5⅝	5⅝	6⅛	6	5¾	6⅝	6⅝	6
	2	..	3⅝	5	..	5	5⅛	..	5⅛	5
Fore ,, ..	1	4	4	3¾	4⅛	4⅛	3¾	3⅞	4	3½
	2	..	3	3⅝	..	3⅝	3¾	..	3	3¼
Brazilian Chilled—										
Hind Quarters ..	1	..	..	4	..	..	4¼	..	..	4½
	2	..	..	3¾	..	..	4	..	..	4
Australian Frozen—										
Hind Quarters ..	1	..	..	3¾	..	..	3¾	..	..	3¾
	2	..	..	..	..	..	..	..	..	..
Crops	1	..	..	2⅞	..	..	2⅞	..	..	2⅞
	2	..	..	..	..	..	..	..	..	..
New Zealand Frozen—										
Hind Quarters ..	1	..	..	3⅝	..	..	3⅝	..	..	3⅝
	2	..	..	..	..	..	..	..	..	..
Fore ,, ..	1	..	..	2¾	..	..	2¾	..	..	2¾
	2	..	..	..	..	..	..	..	..	..
MUTTON:—										
Hoggs, Blackface ..	under 60 lb.	9	8⅜	9	10⅞	10⅛	10¾	12½	12⅝	12¾
	60 lb. & over	8½	..	8¾	10⅜	..	10⅜	11⅞	..	12
,, Cross ..	under 60 lb.	9	8⅜	9	10⅞	10⅛	10¾	12½	12⅝	12¾
	60 lb. & over	8½	..	8¾	10⅜	..	10⅜	11⅞	..	12
Ewes, Cheviot ..	1	..	6⅝	7¾	..	7⅝	9	..	7⅞	8⅝
	2	..	..	7½	..	..	8½	..	..	8⅛
,, Blackface ..	1	7⅛	6⅝	7¾	8⅝	7⅝	9	9	7⅞	8⅝
	2	6⅝	..	7½	7¾	..	8½	8	..	8⅛
,, Cross	1	6	6⅝	7¾	6¾	7⅝	9	7¼	7⅞	8⅝
	2	5	..	7½	5¾	..	8½	6¼	..	8⅛
Argentine Frozen ..	1	..	..	3¾	..	..	3¾	..	..	3¾
	2	..	..	..	..	..	..	..	..	..
Australian ,, ..	1	..	5¾	4	..	5⅝	4	..	5⅜	4
	2	..	4⅝	..	..	4⅛	..	..	3¾	..
New Zealand ,, ..	1	..	..	4⅞	..	..	4¾	..	..	4¾
	2	..	..	4⅛	..	..	3⅞	..	..	3⅞
LAMB:—										
Home-fed	1	..	..	10¾	17⅜	15	16¼	17	14⅝	15¼
	2	..	..	9	16⅜	..	11¼	16½	..	12¾
New Zealand Frozen	1	..	7⅝	7¼	..	7⅝	7⅜	..	7⅞	7⅜
	2	..	7	6¾	..	6¾	..	..	6⅞	..
Australian ,, ..	1	..	..	6	..	..	6½	..	..	6½
	2	..	..	..	..	..	..	..	..	..
Argentine ,, ..	1	..	..	6	..	..	6½	..	..	6½
	2	..	..	..	..	..	..	..	..	..
PORK:—		per cwt s. d.	per cwt s. d.	per cwt. s. d.	per cwt. s. d.	per cwt s. d.	per cwt s. d.	per cwt s. d.	per cwt s. d.	per cwt s. d.
Home-fed	1	88 8	88 8	84 0	88 8	87 1	84 7	84 0	81 8	86 4
	2	49 0	..	72 4	56 0	..	72 4	52 3	..	72 4
Imported	1	..	..	56 0	..	..	56 0	..	..	56 0

EGGS : Monthly Average Wholesale Prices at Aberdeen, Kilmarnock, Lanarkshire, and Glasgow

PROVISIONS : Monthly Average Wholesale Prices (per cwt.) at Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

Description	Weight per 120	Quality	March	April	May
	lb.		s. d.	s. d.	s. d.
ABERDEEN—					
Country .. .. per doz.	..	1	0 9	0 8¾	0 9
	..	2	0 8¼	0 8¼	0 8¾
Duck .. .. ,,	..	1	0 9¾	0 10¼	0 10
	..	2	..	0 10	0 9½
KILMARNOCK—					
Country (ungraded) per doz.	..	1	0 10	0 10	0 10
LANARKSHIRE—					
Country "Standard" per doz.	..	1	1 1	0 11½	1 0
GLASGOW—					
National Mark—					
"Special" .. per doz.	..	..	0 11¼	0 11¼	0 11
"Standard" .. ,,	..	..	0 10½	0 10½	0 10
"Medium" .. ,,	..	..	0 9½	0 9½	0 9¼
"Special" .. per 120	..	..	9 4	9 4	9 1
"Standard" .. ,,	..	..	8 7	8 8	8 5
"Medium" .. ,,	..	..	7 11	8 1	7 8
Northern Ireland ,,	17	..	9 4	9 5	9 2
,, .. ,,	15½	..	8 4	8 8	8 5
,, (Duck) ,,	..	1	10 1	8 10	7 8
,, ...	..	2	..	..	7 5
Irish Free State .. ,,	16	..	7 9	8 1	8 2
,, .. ,,	15	..	7 5	7 7	7 8
,, "Medium" ,,	..	..	6 8	7 2	7 4
,, (Duck) ,,	..	1	10 4	8 5	7 3
,, ,, ,,	..	2	8 5	..	6 11
Danish .. .. ,,	15½	..	7 10	8 2	7 11
,, ... ,,	14	..	6 9	..	..
Polish Blue		1			5 6

Description	Quality	March	April	May
		s. d.	s. d.	s. d.
BUTTER—				
Irish Creamery	1	..	74 0	79 7
,, (unsalted)	1	..	78 0	82 0
Australian	1	77 9	76 6	77 10
	2	74 9	74 9	74 0
,, (unsalted)	1	..	78 0	80 0
Danish	1	96 6	88 6	91 2
,, (unsalted)	1	99 3	91 9	94 0
Dutch	1	..	74 8	75 10
New Zealand	1	77 6	76 9	79 10
	2	76 0	75 8	76 0
,, (unsalted)	1	80 0	79 0	81 10
Swedish	1	79 6	78 9	79 5
CHEESE—				
Cheddar	1	80 0	80 0	80 0
	2	56 0	56 0	56 0
Cheddar Loaf	1	76 0	76 0	76 0
	2	70 0	70 0	70 0
Dunlop	1	80 0	80 0	80 0
	2	49 0	49 0	52 5
Canadian	1	60 0	60 0	60 0
	2	56 0	56 0	56 0
New Zealand (Coloured) ..	1	51 3	48 0	48 5
,, (White)	1	49 6	48 0	48 0
HAMS—				
Irish (Smoked)	1	152 0	152 0	152 0
	2	132 0	134 6	135 0
American (Long Cut, Green) ..	1	102 0	95 9	93 2
,, (Short Cut, ,,) ..	1	98 9	91 3	88 2
Canadian (Long Cut, ,,) ..	1	102 4	96 9	94 2
BACON—				
Ayrshire (Rolled)	1	130 8	120 0	120 0
	2	120 0	112 0	112 0
English Wiltshire (Green) ..	1	105 6	97 6	98 0
,, (Dried or Smoked) ..	1	111 6	102 9	103 2
Irish (Green, Wiltshire Style) ..	1	98 6	96 0	96 7
,, (Dried or Smoked) ..	1	104 6	102 0	104 7
,, (Long Clear)	1	113 6	110 0	107 2
Canadian Sides (Green) ..	1	88 6	76 9	81 10
Danish Sides	1	99 6	87 3	88 10
Dutch (Green, Wiltshire Style)	1	105 6	97 9	104 10

Fruit and Vegetables: Monthly Average Wholesale Prices at Glasgow.

(Compiled from Returns received from the Department's Market Reporter)

Description		Quality	March	April	May
Fruit:—					
Apples—	per		s. d.	s. d.	s. d.
American	case.†	1	11 3	11 11	12 3
,, ...	barrel.††	1	27 3	30 6	32 4
Australian	case.†	1	..	12 10	10 11
Pears, Californian ..	box.‖	1	16 2	16 0	15 3
Vegetables:—					
Beet	cwt.	1	4 6	4 0	3 7
Cabbage, Scottish ..	dozen.	1	..	..	1 6
,, Coleworts ..	,,	1	1 1	1 3	1 2
,, Red	,,	1	2 9	2 8	3 0
,, Savoy	,,	1	2 6	..	..
Carrots, British	cwt.	1	10 6	11 9	12 3
,, Dutch	,,	1	9 8	10 11	10 0
Cauliflowers—					
Broccoli, Cornish ..	dozen.	1	5 6	4 3	4 0
Other British	,,	1	4 0	3 5	3 5
French	,,	1	5 10	4 8	..
Italian	,,	1	7 0	5 6	..
Celery	bunch.	1	1 10	1 8	..
Cucumbers	dozen.	1	10 0	8 0	6 0
Greens	bunch	1	0 6	0 6	0 6
Leeks	dozen bunches.	1	2 0	2 4	2 2
Lettuce, Cabbage ..	dozen.	1	2 10	2 0	1 10
Onions, *Spring*	bunch.	1	0 8½	0 8	0 5
,, *Dutch*	bag.**	1	6 2	5 0	3 5
,, *Egyptian*	,, §	1	..	8 0	6 7
,, *Valencia* ..	case.††	1	11 6	14 0	..
Parsley	cwt.	1	25 0	42 0	15 2
Parsnips	,,	1	15 0	19 0	18 0
Radishes	dozen bunches.	1	2 6	2 2	2 0
Rhubarb	cwt.	1	25 6	14 6	3 4
Spinach	stone.	1	8 0	4 9	3 5
Tomatoes, Scottish ..	lb.	1	..	..	1 6
,, Canary ..	,,	1	0 3½	0 5½	0 4½
,, Channel Islands	,,	1	..	1 10	1 0
,, Dutch ..	,,	1	..	..	0 11
Turnips	cwt.	1	1 9	1 9	1 11

† 40 lb. (approx.). †† 9 stone (approx.).
** 7½ stone (approx.). ‖ 46 lb. (approx.). § cwt. (approx.).

POTATOES: Monthly Average Wholesale Prices per ton at Aberdeen, Dundee, Edinburgh, and Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

MARKET	Quality	First Earlies	Second Earlies	Late Varieties – Red Soils – Golden Wonder	Late Varieties – Red Soils – Other	Late Varieties – Other Soils – Golden Wonder	Late Varieties – Other Soils – Other
		£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
MARCH							
Aberdeen ..	1	..	..	..	..	3 10 8	2 5 0
Dundee ..	1	..	..	..	..	3 15 0	2 10 0
Edinburgh ..	1	..	..	..	..	..	..
Glasgow ..	1	..	2 0 0	..	..	3 17 6	2 5 0
APRIL							
Aberdeen ..	1	..	..	..	..	3 7 6	2 2 6
Dundee ..	1	..	..	..	..	3 11 3	2 5 0
Edinburgh ..	1	..	..	..	..	..	..
Glasgow ..	1	..	1 15 0	..	..	3 8 9	2 1 3
MAY							
Aberdeen ..	1	..	..	..	..	3 15 0	2 5 0
Dundee ..	1	..	..	..	..	4 0 0	2 4 0
Edinburgh ..	1	..	..	..	..	..	..
Glasgow ..	1	..	1 15 0	..	..	3 13 0	2 2 6

ROOTS, HAY, STRAW, AND MOSS LITTER: Monthly Average Prices per ton at Aberdeen, Dundee, Edinburgh, and Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

MARKET	Quality	Roots – Carrots	Roots – Yellow Turnips	Roots – Swedes	Hay – Rye Grass and Clover	Hay – Timothy	Straw – Wheat	Straw – Barley	Straw – Oat	Moss Litter
		s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d	s. d.	s. d
MARCH										
*Aberdeen ..	1	..	..	..	68 9	..	..	..	38 9	..
†Dundee ..	1	..	..	ø14 9	90 0a 80 0b	..	45 0	..	45 0	..
‖Edinburgh ..	1	..	..	..	80 0a 80 0b	..	25 0	..	25 0	..
aGlasgow ..	1	..	..	..	70 0	80 0	35 0	..	37 6	30 8e
APRIL										
*Aberdeen ..	1	..	..	..	73 9	..	..	..	36 3	..
†Dundee ..	1	..	..	ø14 3	90 0a 80 0b	..	45 0	..	45 0	..
‖Edinburgh ..	1	..	..	..	80 0a 80 0b	..	25 0	..	25 0	..
aGlasgow ..	1	..	..	..	70 0	80 0	35 0	..	37 6	30 10e
MAY										
*Aberdeen ..	1	..	..	..	74 0	..	..	..	37 6	..
†Dundee ..	1	..	..	ø15 7	90 0a 80 0b	..	45 0	..	45 0	..
‖Edinburgh ..	1	..	..	..	81 0a 81 0b	..	25 6	..	25 6	..
aGlasgow ..	1	..	..	..	70 0	80 0	35 0	..	37 6	31 0e

* Ex farm, loose.
† Baled straw, delivered in town.
ø Delivered in town.
‖ Bunched or baled straw, delivered.
a Baled and delivered.
b Delivered, loose.
e Home moss litter, in $1\frac{1}{2}$-cwt. bales.

Feeding Stuffs: Monthly Average Prices per ton at Glasgow and Leith.

(Compiled from Returns received from the Department's Market Reporters)

Description	March						April						May					
	Glasgow			Leith			Glasgow			Leith			Glasgow			Leith		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Linseed Cake—																		
Home	8	13	5	8	10	0	8	12	6	8	10	0	8	16	6	8	16	0
Foreign	8	14	1		..		8	13	2		..		8	10	0		..	
Decort. Cotton Cake ..	7	7	6		..		7	7	6		..		7	0	9		..	
Undecort. Cotton Cake—																		
Egyptian (Home manufactured)	4	12	6	4	11	3	4	11	11	4	7	6	4	10	0	4	6	6
Palmnut Kernel Cake ..	7	0	0		..		7	0	0		..		7	2	0		..	
Soya Bean Cake	7	0	8		..		6	13	9		..		6	10	0		..	
Coconut Cake	7	2	6		..		7	2	6		..		7	8	6		..	
Groundnut Cake, undecort.— (40 % Oil and Album.) ..		..		6	15	0		..		6	0	0		..		5	13	0
Maize Germ Cake, Home mfd.	6	13	5		..		6	15	8		..		6	15	6		..	
Maize Germ Meal	6	10	0		..		6	8	4		..			..			..	
Rice Meal	4	1	11	4	1	11	4	0	0	3	16	3	4	2	0	3	18	2
Bean Meal	8	3	9	7	4	5	8	3	2	7	8	2	8	3	0	7	9	0
Barley Meal	5	16	11	6	0	0	5	15	4	6	0	0	5	18	9	6	0	6
Fish Meal	15	10	0	15	10	0	15	5	8	14	18	9	14	16	6	14	13	0
Maize Meal—																		
Home manufactured ..	6	0	4	5	13	9	5	18	2	5	13	9	5	13	0	5	7	6
Locust Bean Meal	7	13	2	7	0	0	7	15	0	7	0	0	7	15	0	7	0	0
Maize Gluten Feed (Paisley)	5	2	6		..		5	2	6		..		4	18	6		..	
Maize—																		
Plate	5	1	7	4	18	9	4	19	5	4	15	8	4	14	6	4	10	0
Oats—																		
Home	6	12	2	6	3	2	6	8	5	5	18	2	6	5	3	5	12	6
Plate	6	7	10	5	18	4	6	6	11	5	15	0	6	4	0	5	10	0
Barley—																		
Imported	4	17	10	4	15	0	4	17	6	4	15	0	5	0	0	4	18	0
Wheat—																		
Home	5	9	1	5	2	6	5	10	4	5	2	6	5	13	9	5	2	6
„ (Poultry)	5	2	6		..		5	6	3		..		5	7	6		..	
Imported	6	1	3	5	1	3	5	18	9	5	2	6	5	18	6	5	0	8
Middlings (Fine Thirds or Parings)	5	13	9	5	13	2	5	12	10	5	10	0	5	19	0	5	9	6
Sharps (Common Thirds)	5	18	2	5	14	5	5	12	10	5	11	3	5	4	0	5	6	6
Bran (Medium)	5	17	6	5	17	6	5	13	9	5	11	11	5	7	3	5	8	6
„ (Broad)	6	6	11	6	8	9	6	3	2	6	6	11	5	16	3	6	0	0
Malt Culms	4	14	5	4	10	0	4	12	6	4	10	0	4	8	6	4	2	6
Distillers' Mixed Grains (Dried)		..		5	18	9		..		5	18	9		..		5	15	6
Distillers' Malt Grains (Dried)	6	2	2		..		5	18	9		..		5	13	0		..	
Brewers' Grains (Dried) ..	5	3	5	4	11	3	5	1	7	4	10	0	4	19	0	4	5	0
Crushed Linseed	15	10	0		..		15	7	6		..		15	2	0		..	
Locust Beans (Kibbled and Stoned)	6	15	11	6	15	0	6	15	0	6	15	0	6	15	3	6	15	0
Beans—																		
China	7	5	0		..		7	5	0		..		7	5	0		..	
English	8	6	3		..		8	7	6	7	10	0	8	2	6	7	10	0
Egyptian	7	2	10	7	0	0	7	2	10	7	2	6	7	3	9	7	2	6
Rangoon (White) ..		..		5	15	0		..		5	15	0		..		5	15	0
„ (Red)		..		5	15	0		..		5	15	0		..		5	15	0
Persian	7	9	5		..		7	10	0		..		7	10	0		..	
Pease—																		
Calcutta (White)	8	17	6		..		8	10	0		..		8	18	2		..	
Karachi („)	8	10	0		..		8	7	6		..		8	11	11		..	
Feeding Treacle	4	16	3	5	2	6	5	0	0	5	4	5	5	3	0	5	9	0
Sugar-Beet Pulp (English) ..	5	5	8	5	3	2	5	6	7	5	1	3	5	4	3	4	19	3
„ „ „ (Irish) ..	5	2	2		..		5	1	3		..		5	2	0		..	
Linseed Oil, per gall. ..	0	4	0		..		0	4	0		..		0	4	0		..	

FERTILISERS : Monthly Average Prices per ton at Glasgow and Leith.

(Compiled from Returns received from the Department's Market Reporters)

Description	Guaranteed Analysis	March Glasgow	March Leith	April Glasgow	April Leith	May Glasgow	May Leith
	%	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Nitrate of Soda *	N. 15·5	7 18 6	7 18 6	7 18 6	7 18 6	7 18 6	7 18 6
Sulphate of Ammonia (Neutral and Granular) * ..	N. 20·6	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0
Calcium Cyanamide †	N. 20·6	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0
Nitrochalk * ..	N. 15·5	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0
Superphosphate ..	P.A. 13·7	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6
,, ..	,, 16·0	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6
,, ..	,, 18·3	3 2 6	3 2 6	3 2 6	3 2 6	3 2 6	3 2 6
Ground Mineral Phosphate ** ..	P.A. 26	2 7 6	2 10 0	2 7 6	2 10 0	2 7 6	2 10 0
,, ,, ,, ** ..	,, 34	3 7 6	3 10 0	3 7 6	3 10 0	3 7 6	3 10 0
Potassic Mineral Phosphate	P.A. 18 Pot. 10	3 16 3	..	3 16 3	..	3 16 3	..
,, ,, ,,	P.A. 18 Pot. 9	..	3 10 0	..	3 10 0	..	3 10 0
,, ,, ,,	P.A. 20 Pot. 7·5	3 10 0	..	3 10 0	..	3 10 0	..
,, ,, ,,	P.A. 21 Pot. 5	3 5 0	..	3 5 0	..	3 5 0	..
,, ,, ,,	P.A. 21 Pot. 6	..	3 2 6	..	3 2 6	..	3 2 6
Kainit (in bags) ..	Pot. 14	3 8 6	3 2 6	3 8 6	3 2 6	3 8 6	3 2 6
Potash Salts ..	Pot. 20	4 0 0	3 12 6	4 0 0	3 12 6	4 0 0	3 12 6
,, ,, ..	,, 30	5 7 6	4 17 6	5 7 6	4 17 6	5 7 6	4 17 6
Muriate of Potash (on basis of 80 per cent purity)	Pot. 50	9 5 0	8 15 0	9 5 0	8 15 0	9 5 0	8 15 0
Sulphate of Potash (on basis of 90 per cent purity)	Pot. 48·6	10 12 6	10 0 0	10 12 6	10 0 0	10 12 6	10 0 0
Steamed Bone Flour	N. 0·8 P.A. 28	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0
,, ,, ,,	N. 1 P.A. 30	..	..	..	..	..	..
Bone Meal (Indian)	N. 4 P.A. 20	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0
Potassic Slag	P.A. 12 Pot. 6	..	3 10 0	..	3 10 0	..	3 10 0
Basic Slag ‡ ..	P.A. 12	2 5 0	..	2 5 0	..	2 5 0	..
,, ,, ..	,, 13	2 6 0	..	2 6 0	..	2 6 0	..
,, ,, ..	,, 14	2 8 0	..	2 8 0	..	2 8 0	..
,, ,, ..	,, 15	..	2 10 0	..	2 10 0	..	2 10 0
,, ,, ..	,, 15·75	..	2 12 6	..	2 12 6	..	2 12 6

Abbreviations :—N. = Nitrogen ; P.A. = Phosphoric Acid ; Pot. = Potash.

* Carriage paid, in 6-ton lots. † Carriage paid, in 4-ton lots.

** Fine grist, 90 per cent. fineness through prescribed sieve.

‡ Basic Slag :—At Glasgow—80 per cent. citric soluble and 80 per cent. fineness ; f.o.r., in 6-ton lots.
At Leith—80 per cent. citric soluble ; on rail, in 2-ton lots.

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PROGRESS AND PLANNING IN AGRICULTURE [1]

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Ever since the beginnings of civilisation the rate of improvement in agricultural technique has controlled and conditioned, to a considerable degree, the progress of the human race. This progress has been of two kinds—on the one hand an increase of numbers, and on the other a rise in the standard of life.

At certain times and places better farming has meant no more than the possibility of a given level of subsistence for an increasing number of people. Indeed, where the available land has been limited, where conditions of climate and the like have favoured the increase of population, and where the progress of agriculture has been relatively slow, we find all the essential features of that rather gloomy picture of man's economic destiny which Malthus conceived as normal. Broadly speaking, this has been the state of things in China during many centuries. Conditions among the Western nations have, however, become more and more unlike those that Malthus presupposed. He assumed that populations tend to increase in geometric progression, whereas in many countries population is already, or is rapidly tending to become, static. He assumed that the additional land, brought under cultivation in order to meet man's growing necessities, would be inferior in some respect to that already farmed ; but at present the tendency upon the whole is for farm land to go out of cultivation. Malthus could foresee no more than a slow and dwindling rate of increase in the productivity of the soil, each successive increment being obtained at the cost of a progressively greater amount of human toil ; but recent additions to scientific knowledge have been enough to outweigh the effects of the economists' law of diminishing returns ; our increasing output of food is being secured with less and less toil, instead of more and more. The main result of the most recent agricultural progress in the more advanced countries has been then to set free, for activities other than food production, an increasing proportion of the population, with, as a secondary consequence, the possibility of an unprecedented rise in standards of life.

[1] Presidential Address delivered to Section M of the British Association at Aberdeen.

Before, however, we attempt to analyse the present situation of our industry, or try to predict its future, it may be well to cast our eyes back over some of the main stages in its evolution. This is the easier to do because on each of the main steps of the ladder some part of the human race has been left standing—providing a living relic of what was once perhaps the most advanced type of economic life.

We have indeed—in Australia, in Ceylon, in Africa and elsewhere (and often under conditions quite favourable to agriculture)—remnants of those peoples who refused to become either tillers of the soil like Cain, or keepers of sheep like Abel. With them—women and children as well as men—life consists of an unremitting food-quest. Their dietary includes articles like grass seeds, insect grubs, mice and snakes, yet they are often reduced to hunger and famine. They must wander over wide areas to secure their meagre fare and they have neither time nor energy to spare for the arts of civilisation. It is worth noting that their fundamental disability is a lack neither of intelligence nor of manual dexterity, but of foresight. They cannot see beyond their immediate necessities. They will work for a daily wage but not for a yearly harvest. The Bushmen of South-West Africa, for example, can be trained to become capable herdsmen, but they never become independent stock-farmers, because they cannot resist the temptation to kill when they are hungry.

When men first began clearly to anticipate their material needs, and to plan ahead in order that these might be supplied, they naturally strove to bring under control those species of plants or animals on which, in their earlier unplanned economy, they had been accustomed to rely. Thus the big-game hunters of the Asiatic plains became, in course of generations, nomadic herdsmen. In the flood valleys of the Nile and Euphrates unaided nature solved what has elsewhere been the chief problem of the cultivator—the maintenance of the fertility of the soil—and there the greatest of our early civilisations were founded upon an assured supply of corn. But the herdsmen who have become nothing more have condemned themselves to a very limited and an insecure existence. They may build up immense capital in the form of live stock, but they still live in tents and subsist entirely on meat and milk, or, like the Masai, on blood and milk; and a drought or an epidemic of stock disease may reduce them, in a few weeks, from a state of plenty to one of famine.

Again the cultivators who have clung to plant life alone as a means of sustenance maintain, except in specially favourable localities, but an inconclusive war with nature. On the one hand, the maintenance of soil fertility without animal manure has been usually, until the recent introduction of other fertilisers, a nearly insoluble problem; hence land, becoming exhausted after a few years of tillage, has had to be again abandoned until such time as

natural processes should restore its fertility. The periodic clearing of new areas, added to the routine operations of tillage, and both carried out by means of primitive hand tools, give a very real meaning to the curse of Cain. Finally, a purely vegetable diet, often restricted to one or two specially productive plants, may be not only monotonous but seriously deficient in nutritive value.

The contriving of a system of mixed farming, embracing both plants and animals, was a remarkable stage in the progress of civilisation. It has been surmised that it came about through the conquest of the cultivator peoples of Egypt and Mesopotamia by herdsmen peoples from the north-east. The combination did many things. It made possible the application of animal power to the soil. It enabled permanent agriculture to replace shifting cultivation. It provided at once greater abundance, more variety and greater security in the food supply. It enabled men to fix their abodes and thus made worth while the building of permanent dwellings and the accumulating of household goods. It set free human energy for the arts of civilisation. In short, it enabled the men who devised it to inherit the earth.

But life for these innovators became not only fuller but also more complicated. Man had to organise the food supply not only of his family, but also of his beasts, and to this end he had to bring under cultivation new species of plants and invent new methods of fodder conservation. As the mixed farmers spread over the world they had continually to exercise their ingenuity in adapting their system to the varying natural conditions of their new homes.

This system was improved and modified during ancient and medieval times without undergoing any fundamental change. There was a minor hiving off of other industries from farming and a consequent growth of trade ; there were some temporary experiments in the mass production of food, especially by the Romans and by means of slave labour. But up till the time of the industrial revolution the typical citizen of the civilised world was the family farmer, looking to his own land to supply the bulk of his material needs and producing but little for sale. He remains to-day the typical citizen of many great and populous countries, and his class is easily the most numerous in the world.

But the eighteenth century saw the beginnings of another great change. Primarily this had little to do with the business of growing food or other farm produce. It concerned what had hitherto been but minor industries, occupying the time of the farmer and his wife in winter evenings or employing a few village craftsmen—industries like the spinning of yarn and the weaving of cloth, the fashioning of ploughshares and of cart wheels. The successful application of mechanical power to these manufactures meant their removal to convenient sources of power, and, therefore, their removal from the farm. The separation of agriculture from other industries meant an increase in the exchange of goods, and this necessitated, in turn,

the provision of improved means of transport and a great increase in the supply of money and credit.

The agricultural changes which accompanied the industrial revolution were changes of organisation rather than of technique. There was (with the possible exception of Meikle's threshing machine) no new agricultural invention comparable to the spinning mule, the power loom, the new blast furnace or the steamship. The successful application of mechanical power to the soil was not to be achieved for another hundred years. But farmers had to replan their industry with their eyes upon a market rather than upon their own personal requirements. This favoured a degree of specialisation in production that had hitherto been impossible. It favoured a larger type of enterprise and led to the engrossing of farms. Because of the disappearance of the old fill-time home industries, it necessitated a replanning of farm work. It required, of course, the investment of fresh capital, and thus gave the whip hand, within the industry, to those individuals with capital to command.

The revolution was not carried through without a good deal of hardship to individuals—some of which, according to modern standards, amounted to grave social injustice. The enclosures of the old open-field villages of the English Midlands and the Highland clearances need only be mentioned in this connection.

Indeed, there have been difficulties and hardships associated with all the major steps of progress that we have traced. Each departure from tradition required a fresh effort of will and made a new demand for courage and enterprise. At every stage there were people who thought that things were very well as they had been; but these people have always been wrong. No reasonable interpretation of history can leave us in doubt that each great step in economic evolution has been amply justified. It is not only that a higher level of material prosperity has been attained, but that, upon the whole, this material prosperity has been turned by men to good account. No reasonable person would wish to return to the life of the Australian aborigine, the nomad or the African cultivator upon his patch of maize and yams. Many people feel, indeed, a strong if rather sentimental attraction towards the old peasant way of life. This is easy to understand, for most of us are removed but a generation or two from peasant homes. In truth, the modern business farm suffers, in some ways, by comparison with the peasant holding; but only, as I believe, because we have not as yet fully succeeded in translating the economic advantages of the former into social good. The broad lesson of history, as I see it, is that we must take our courage in both hands and face the task that we now see before us.

For some of the origins of our present agricultural problem we must go back to the seventies of last century, which marked the end of what has been called the golden age of British farming. At that time, in those countries where agriculture had been separated

from the other industries, the division of national incomes between the two classes was favourable to the agriculturist—he got fair value, in terms of manufactured goods and services, for his labour and enterprise. It is true, indeed, that where the agricultural class was divided into landlords, tenants and labourers there was, according to modern standards, a very inequitable division, as between rent, profit, and wages, of the net gains from farming; but this inequity was by no means peculiar to farming.

Since the seventies the productive capacity of agriculture has constantly tended to increase more rapidly than the demand for agricultural produce. The one check in the process was caused by the Great War, but this has already been more than made good. The result has been that, except during the period from 1917 till 1921, when the boot was certainly on the other leg, agriculturists have failed to secure a due reward for their increasing efficiency.

The rise in the output of world agriculture has been made possible, firstly, by a vast increase in the area of available land, and in supplies of the farmer's other primary raw materials. The process of expansion began with the opening up of the North American prairie for corn growing, following the building of railways and the invention of the binder. At first it was confidently predicted that the flood of corn would be only temporary, since a few years of "prairie farming" must exhaust the most fertile soil in the world. But the prairie soil was found to be different stuff from that of Western Europe, and its exhaustion proved to be a vain hope, or a groundless fear, according to the point of view. Moreover, one new country after another went through the process of agricultural development, and the problem of transport was solved not only for corn and wool, but also for meat, dairy produce, fruit and, indeed, for every commodity, except the most bulky or the extremely perishable. But it is not only transport developments that have thrown open new fields to the farmer. Irrigation schemes and dry-farming technique have added great areas of what was formerly desert. Plant breeders, by producing quick-maturing strains of plants, have extended the northern limits of cultivation by a belt that embraces hundreds of millions of acres. The growing control of human and animal disease is creating the possibility of settlement and agricultural development over vast areas of the tropics which, as yet, have been hardly touched. Thus the old fear of overpopulation, which has coloured so much of past economic thought, has been removed to a distance that now seems incalculably far.

Apart from land, the most important of the farmer's primary raw materials are fertilisers, and here it is enough to say that there can be no anxiety about future supplies. The crisis in connection with the supply of nitrogen, which seemed thirty years ago to be approaching fast, has been completely averted. Nitrogen is now available to the farmer, in infinite quantity, at less than half its pre-war price.

The other cause of the growing abundance of agricultural produce has been, of course, the application of the rapidly increasing body of scientific knowledge to the business of plant and animal production. It is unnecessary to give a catalogue of recent advances in agricultural science, or to show how these have been translated by the farmer into improvements in practice. Two or three examples will suffice. The latest report on the Agricultural Output of England and Wales shows that (through the application of the sciences of genetics and nutrition) the average output of eggs, per bird, increased by 20 per cent. in six years. The use of the tractor and the combine harvester enables a reduction, in the labour cost of corn production, of more than 50 per cent. The output of meat, per acre of grassland, has been increased, at Cockle Park and on much similar land elsewhere, by more than 100 per cent., through the use of what was once a worthless by-product of our steel industry. A simple and cheap remedy has been found, almost the other day, for the "rot" in sheep, which has often in the past killed a million sheep and more in a single year. And so on—more farm land and more fertilisers, more machines and more science, all leading to the same result of cheaper, easier, and more abundant production.

I am not suggesting that overproduction is the sole cause of the present crisis in world agriculture. Indeed, the immediate cause is the fall in the general price level following the contraction of currency. But a tremendous fall in prices, due to the same cause, occurred at the end of the Napoleonic wars without causing the general ruination of agriculturists. The severity of the present crisis has been due, as I see the matter, to the preceding long period of inadequate returns in agriculture, which left the industry with depleted capital and a burden of debt, and therefore unfit to withstand a period of general economic disorganisation. If the significance of rapid agricultural progress had been realised in time, and if nations had been prepared to accept its logical consequences, there might have been no necessity to-day to devise any revolutionary economic plan for the industry. For instance, it might have been foreseen that the cheap producer in the new countries must displace the dear producer in the old, and that as Canadian prairie was broken up, Midland clays must go down to grass. But no country was prepared to accept either a decline in the number of its agriculturists or a reduction of its home output of food. Rural depopulation was viewed with widespread alarm, and the extensification of farming was regarded as an evil implying almost moral turpitude on the part of the farmer. Again it might have been seen that, the world's requirements of bread being amply met, some of the surplus energies of farmers might have been diverted to the production of more interesting commodities like fruit or chickens or tobacco. But States, when they intervened at all, did so in the opposite sense—encouraging the production of the old necessaries and discouraging the expansion of consumption of luxuries. Such

ideas die hard. It is still considered a meritorious thing to employ an agricultural labourer, but there is no particular feeling about the employment of barbers, haberdashers or electricians. It is somehow more honourable to plough a field than to let it lie in grass. It is a nobler thing to grow wheat (even if nobody wants to eat it) than peaches or strawberries. These notions are a legacy from the time when the world was hungry of necessity, and when people lived healthily in the country but died quickly in the towns. We must realise that these conditions have ceased to be. There is a superabundant organisation for food production, and there is no difficulty about breeding up a good and healthy human stock in the modern city. It seems to me that there is no argument for keeping unnecessary workers in agriculture or for driving people back to the land.

During the past few years there has been a rapidly growing realisation, in one country after another, that the farmer's economic lot was becoming unendurable, and a mass of different expedients have been devised, either by governments themselves or with their sanction and approval, to ensure something like a fair price for agricultural commodities. These measures are based on a wide variety of principles, and some are open to obvious criticism. For example, we have compulsory restriction of output; monetary compensations by the State for restrictions voluntarily made; even plans for the destruction of produce which is judged to be in excess of demand. We have direct State subsidies designed to make good the difference between cost of production and market price; the fixing of internal prices by the State, combined with State control of imports and exports; export subsidies; tariffs designed to raise prices to a desired level; restriction of imports, with or without tariffs, intended to adjust supply to demand. The list is by no means complete. Some of these measures, indeed, are not so much rational means to assist agriculture as the weapons of economic warfare, in which apparently one of the objects of strategy is to force upon the enemy more food than he can eat.

It is perhaps necessary then to restate the fundamental (and essentially very simple) ideas upon which any real scheme of economic planning must be based. In the first place, successful planning necessitates the accurate prediction of demand and implies an undertaking, on the part of producers, to deliver the quantity of goods required. In the second place, it involves the fixing of a price for the commodity in question which will allow the producer a reasonable, and no more than a reasonable, reward, and only provided that (1) his technical methods and general management are reasonably efficient, and (2) the natural conditions and economic situation of his farm are reasonably favourable to the production of the said commodity.

That the translation of these ideas into practice must be a hard task is obvious. Demand is not static, but is subject both to

long-term changes and to temporary fluctuations, due to causes that are some of them accidental and some of them obscure. Planning must anticipate an increase of consumption demand, and indeed endeavour to stimulate it. Again, agricultural production is still subject to the accident of drought, epidemic disease and so forth. The determination of farming costs on which, under a planned economy, prices must be based is beset with rather special difficulties. Some people feel that these objections to planning are insuperable, and that the system presupposes a measure of understanding between one producer and another, between exporting and importing countries and between producer and consumer that is quite beyond the bounds of reasonable expectation. Indeed, if the crisis had been less urgent, the institution of our marketing schemes should have been preceded by a period of research, experiment and education.

One must protest most strongly against any notion that economic planning is a panacea for all our ills or is any substitute for education and research. The main lesson of the Russian plan for agriculture is not, as I see it, that the basic ideas behind it were wrong—I believe they are essentially right—but that their translation into practice necessitated an increase of scientific knowledge and technical skill, and a change of economic and social outlook that could not be attained at the rate which the plan contemplated. There is a risk, I believe, that we shall fall into the same error and suffer some of the same consequences. Another danger inherent in planning is that it may be used primarily to further narrow national ends, thus becoming only another weapon in the armoury of economic war. It is easy to see how it might be used, in this country, with the chief objects of increasing our agricultural area merely at the expense of that of other countries; of increasing our home production of food merely by causing a reduction elsewhere; of finding jobs for our unemployed by throwing overseas producers out of work. It is, of course, true that scientific and industrial progress is making countries, in some respects, less dependent one upon another. Italy by developing her water power has reduced her need of our coal; we, by building Billingham Works, have lessened our requirements for Chilean nitrate. Some increase of self-sufficiency is the inevitable consequence of progress. But it is still true that civilised countries depend largely—for the abundance, variety, and security of their food supplies, as well as for many other material blessings—upon a free and large international exchange of goods. World trade has shrunk because our monetary system has been unequal to the task of maintaining its flow. People are idle because they cannot exchange, one with another, the things which they might produce. Mere one-sided restrictions on trade can form no part of any sane plan. International trade agreements, indeed, are an essential part of any scheme.

Supposing that the marketing schemes succeed in restoring a

level of moderate profitability to agriculture, there will still remain the considerable task of reconditioning our farms. Apart from the period of two or three years at the end of the war there has been no business inducement, for more than half a century, to put fresh capital into farming. Many of our existing buildings were planned at a time when wages were at less than a third of the present rates, and therefore with little regard to economy of labour. Some farms are of an uneconomic size in relation to modern kinds of equipment. There are heavy arrears in the matter of plant and machinery renewals, of drainage and liming. There is also, in many cases, a heavy burden of debt.

In some countries the problem of farmer indebtedness is so acute that it has been thought expedient for the State to intervene, e.g. by prohibiting mortgage foreclosures, by proclaiming moratoria on mortgage interest, or by making or guaranteeing loans at specially low rates of interest. These measures have become necessary because the long-continued underpayment of agriculturists has led to the severe depletion of agricultural capital, but in themselves they can provide no permanent solution of the farmer's economic problem, which is one of prices. It would seem that the recapitalisation of the industry could be most quickly brought about by the deliberate raising of prices, for a short period, somewhat above the "fair" level as previously defined. The profits made would undoubtedly be largely reinvested in farming, and new capital would be attracted. Moreover, after a long period of under-payment, a short period of over-payment is no more than the farmer's due.

Reorganisation presents the greatest difficulties in the case of those branches of the industry which, so far as can be foreseen, must suffer a permanent reduction of demand for their products. A case in point is the production of oats which has been from immemorial times one of the main departments of farming in this part of Britain. The general rise in the standard of living is causing a general decline in the use of oats for human food, and the substitution of mechanical for horse transport is gradually killing the alternative market. For other purposes, such as cattle feeding, or the manufacture of starch, etc., there are many competing commodities, such as maize, which are less costly to produce. The case of the northern farmer has a good deal in common with that of the Lancashire cotton spinner—both are suffering from the general depression, but also from a special decline in demand for their particular products. The permanent solution must be gradually to replace the oat crop by some other; and State assistance to this end would be of greater ultimate benefit to the industry than a subsidy or other device to make oat growing again profitable.

Let me conclude by trying to draw a picture of the changes in farming and in rural life that would be both desirable and possible in a world where the principle of a fair price was permanently

established, and where agriculturists would fairly share the benefits from any future improvement in their efficiency as producers. I cannot, as I have already said, foresee any large increase in the numbers of people employed on British farms, or any large schemes of land reclamation which would add materially to our agricultural area. These things can be achieved only at a real and considerable cost to the consumer, for they would imply a displacement of cheap production overseas by relatively dear production at home.

What one can foresee is the rapid spread of a variety of measures of reorganisation calculated to increase the output per unit of labour. Seventy years ago the rent of the land was usually, and by far, the largest single item of the farmer's expenditure ; ordinary farm land might pay a rent of three pounds an acre, while wages were ten shillings a week ; the landlord's share of the net output might easily be twice that of labour. Hence the chief objective in farming was economy of land—high output per acre. Now that land is abundant and rent a comparatively small fraction of expenditure, the chief object must be economy of labour.

There is indeed already a growing tendency to fit the land and the capital to the man rather than the men and capital to the land. This is implied in the use of the word *unit*, which is becoming so common, for example, in relation to pig, dairy, and poultry enterprises. The unit is a department designed with the primary end of providing the optimum amount of work for a whole-time skilled specialist, with or without a limited amount of less skilled or partially trained labour. The man is equipped with a labour-saving device whenever this will make possible an economic increase in his output, and his functions become, to an ever-increasing extent, mental in character.

This kind of change must obviously tend towards an increase in the size of individual departments on the farm—one thinks, for example, of one-man units of 300 pigs or 2000 head of poultry, or of two-men dairy units of sixty or seventy cows—and hence it must often imply either an increase in the size of the farm or, alternatively, some degree of simplification and specialisation of its organisation. This simplification, together with a growing tendency to delegate management to heads of departments, may be expected to reduce management as well as labour costs. Moreover a great part of the function of management in the past has been marketing, and the development of the marketing schemes may be expected greatly to reduce this side of the work. A " clean-boot " farmer on three or four hundred acres of ordinary land will no longer be able to justify his existence.

The carrying out of this kind of reorganisation demands a new standard both of general and of technical education in the farm worker. Indeed, the provision of short courses of instruction for specialist workers—in pig-keeping, milk production, tractor work and the like—is an urgent need. The cash value of skill and

knowledge must grow with the increasing responsibility of the worker.

I well know that the whole idea of "factory farming"—the growth of machinery and the specialisation of labour—is repugnant to many people. The variety of occupations on the one-man mixed farm, the pride of individual ownership and so forth are held to compensate for unconscionable hours of labour and small returns. But I have never been able to see that inhuman personal relationships need necessarily go with specialised occupations, short hours, and high wages. Indeed I believe that, on the factory farm, it is possible to cultivate a kind of team spirit which is essentially a finer thing than the rather narrow independence of the small-holder. In any case, the greatest obstacles to a richer and fuller country life have always been poverty and lack of leisure. If we can remove these obstacles we shall have done much.

SOME TRENDS IN MECHANISED FARMING

I—THE GRAIN HARVEST

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THE usual complaints against mechanised farming—that it will rob the countryside of its beauty, of its labourers, and of their cottages; rob wheat of its value for milling, barley of its even germination for malting; flood the market with grain at unseasonable times, and let high yielding land down to the unthrifty standard of the prairie farms—have two features in common. First, the assumption that the British farmer knows nothing of his own business, which is to make an income out of the land without wasting the capital it represents; and, second, the treatment of mechanisation as some new, surprising and detestable innovation of the present day. With the first assumption no one need dally; but the second depends on what is meant by mechanisation.

Mechanisation, as it is understood by some people, involves the use of internal combustion-engined tractors, with a vague idea that the farm which uses them will carry several thousand acres of indifferent grain, averaging perhaps three quarters per acre in a good year, with a labour staff of one man and a boy, and an owner who watches his profits from a distance and never muddies his boots. To the townsman the reaper and binder does not displace labour, the steam-ploughing tackle is as legitimate a use of power as is the threshing-box; and he regrets the days when a whole countryside, tramps, tinkers and all, was swept to provide harvest labour, while the able-bodied farm workers were bent to the sweated labour of the notched sickle.

There is a great field of fallacy in these and other matters for a vigorous writer to plough with a trenchant pen. Innovations in farming cause far more concern than innovations in any other industry.

In one sense of the word, all farms are mechanised, though some farms are more mechanised than others. A spade is a machine, and in the kailyard it is still an effective machine, though of little use in the ten-acre field. To the engineer a machine is admirable if it does its work effectively ; if it does its work efficiently, that is, with as little possible expenditure of power or money, it is still more admirable, though efficiency is in many cases difficult to assess, and harder still to compass ; and on the farm, at least, in nine cases out of ten, must take second place to effectiveness. To take a simple instance, an engine driving a milking-plant may cost half as much to run as a less efficient type—but if it is a half-hour's labour to start it on a cold morning at 4 a.m., theoretical efficiency and thermodynamics form no part of its owner's thoughts.

The object of this series of notes is to give some account of the changes which are taking place in those sections of the farm which use most machinery ; and of these it is proper that harvesting should come first.

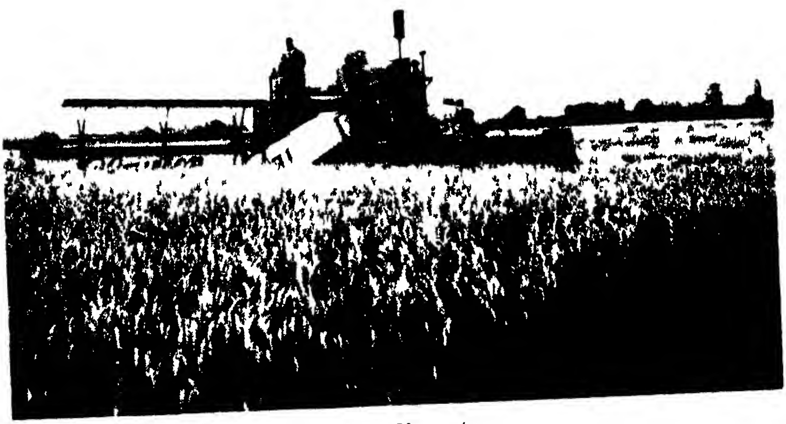
The combine harvester is perhaps the most important new machine which has appeared on British farms in the last ten years, and it is still very much on trial. The first machine of this type was introduced by the Institute for Research in Agricultural Engineering of the University of Oxford in 1928, and this season some sixty were at work. Advocates of this machine claim that it makes possible the growing of cereals at a figure which has never before been attained in this country, and which will indeed compare satisfactorily with the costs of growing in the great producing areas of other continents. Mr Nevile of Wellingore, Lincolnshire, who runs several of these machines, estimates the overall saving of cost, as compared with a reaper and binder and stationary thresher, at at least £1 per acre, taking its costs as 10s. to 18s. as against 35s. to 40s. for the double operation. An equally important claim is that it makes the harvest virtually independent of weather, since a dryer is regarded as an essential part of its equipment. The machine has, on many occasions, been set to work an hour after a fall of rain has ceased, with complete success. The grain to be harvested is allowed to become completely ripe before cutting, since there is no risk of loss from shedding as with the reaper and binder ; and it deals with laid crops at least as well as does the binder, and in general better.

The machine has its opponents. Its high initial cost, when the dryer is taken into account, puts it out of court for holdings where less than 200-250 acres of cereals are grown. It does not make long, clean straw—the straw, indeed, is usually burnt or ploughed in—and though a properly adjusted machine should

"Sunshine" Harvester.

"Sunshine" Harvester—Sacking off.

"Hillside" Type of Combine Rear View



Combine Harvester

leave very few grains or ears behind it—and direct comparison with the binder on this point has shown it to leave less—it does deposit weed seeds with the cavings, and these are not always destroyed in the cleaning up of the stubbles.

Last season there was considerable prejudice against the use of the combine for malting barley. The prejudice—which manifested itself by a flat refusal on the part of many merchants to buy malting barley from a combine, even when sold under a germination certificate—seems to have arisen from the inexpert use of a home-made dryer in one district of England. In any event it should be remembered that malting barley is more sensitive than wheat to excessive drying temperatures, and this sensitiveness increases with the moisture content of the grain. This season the position has been easier, but merchants still require a "declaration." Actually some combined barley has been fetching prices near the maximum given for normally threshed grain; this, however, was harvested by a combine fitted with a "beater" drum instead of the "peg" type more usually found on imported machines. The logical solution as regards malting barley by whatever means harvested, would be that all such grain should be sold under certificate of germination; this would safeguard both grower and maltster.

An important new introduction to English farming practice this season was the Australian "Sunshine" harvester, which has been running near Salisbury on crops yielding up to 8½ quarters per acre. It presents striking differences in design from the more usual type of combine, in that the cutting of the wheat is done at the front of the machine (which is self-propelled, requiring no tractor) by a combination-stripper comb and cutting-bar. The cut heads are collected by two auger-like conveyors, which eliminate the use of "canvases." With this arrangement the straw must, of course, be left standing, but variation in height is of no consequence, and even quite low ears are gathered. The cut stubbles present a most curious sight as they are of widely varying heights. A striking feature of the "Sunshine" is its ability to start work anywhere in the field without previous "opening up," and a lane, for instance, can be cut straight through the centre of a large field, or the edges be taken in one operation without any wastage. When seen working it was obvious that the amount of shed and wasted grain was practically nil: it is said, however, to be less effective than the conventional designs of combine in badly-laid grain, since, having only one engine for forward movement and threshing, it is not possible to "edge" the whole outfit by gradual degrees through the bad patches. The machine works fast, and has covered as much as 25 acres in a working day, its best output being 16½ quarters in one hour. This involves fairly strenuous work for the two hands on the sacking-off platform. It is not yet possible to form any view as to how far this type of

harvester will prove successful in England; this will depend largely on how far it can be adapted to deal with laid crops.

Two new small machines have appeared abroad which may perhaps meet the needs of the farm of less than 250 acres of cereals. The first, made by Allis-Chalmers, has the threshing-drum mounted parallel to the direction of travel and immediately behind the cutter-bar—thus eliminating cross-travel of the cut wheat—and the shaker sieves crosswise instead of lengthways, delivering the straw at one side. It is also mounted on pneumatic tyres. It has not been possible to get one of these machines over this season, and no trustworthy report of its performance is available. The other harvester, which has been described in the German press, is said to cost only a third as much as the standard combines, and, since it is described as being built on to a tractor, is apparently a power take-off machine. It is said to possess two distinctly novel features, in that it has no shaker gear and that the threshing-drum is vertical.

The advent of the Combine has stimulated many attempts to simplify harvesting and threshing for the smaller farm, and the past two seasons, with their exceptionally dry conditions, have favoured them. Threshing direct in the field has been a common sight in the Southern and Eastern Counties of England, and travelling outfits have been fully employed on contract work. The wheat quota scheme has largely eliminated the practice of holding grain in stack "for a rise," with its attendant risks of loss and spoilage by vermin. With a reaper and binder the main problem is the transport of the sheaves to the threshing-box. Motor and tractor hay-sweeps were used last year for this purpose, but the experiment has not been repeated in the few instances under observation, owing to loss of grain by shedding, nor have the several rick-lifting systems made the advances that were expected of them. A development that is being watched with some interest is a modification of a reaper machine originally designed to deal with lucerne and young grass. In this the canvas is lengthened and carried upwards—there is no knotter—to deliver the swath continuously into a rubber-tyred trailer towed alongside. Reports of its performance vary, and one account states that the great bulk of untied grain and straw makes it difficult to get a full load into a trailer.

The future of all new systems of grain harvesting depends very largely on the possibility of the market for straw recovering. There has been some talk of strawboard factories being started in various parts of the country, to attempt to recapture a market at present largely in foreign hands: and it is not clear whether "combine" straw will be suitable. But as recent experiments in Germany have again shown, it is quite possible to produce long straw on a combine if this is fitted with a beater drum instead of the more usual peg drum. Straw baling in the field—using motor sweeps to collect—has been done successfully, and the Oxford Institute last year used

their imported Combine Baler for the same purpose. The Germans are concentrating apparently on straw-trussing machines for this, and a trussing attachment for the combine has recently been marketed in the United States, and will possibly be seen in this country next summer.

Drying equipment for grain has now become almost a commonplace on the larger farms, and though of little use during the last two seasons, much valuable experience has been gained in its handling. The chief point in the management of such farm dryers lies in the avoidance of excessive temperatures : the temptation to dry in a hurry must be resisted. Apart from damage to the grain, every unnecessary unit of water removed means a direct loss to the grower. As millers have long since discovered, it pays to sell water at the price of wheat. Part of the difficulty from the farmer's point of view is to measure his moisture contents : though several cheap and simple methods are known, these take time : and the electrical method—though so instantaneous that every load can be measured as it comes in—is expensive, though the apparatus is less complicated than, say, a two-valve wireless set.

Barn equipment for dealing with harvested grain is becoming something of a problem. Many farmers are now installing bin storage in disused barns, chiefly for barley, the most usual pattern being the "spiked" wooden bin made of 2 inch×2 inch quartering. Elevators and conveyors seem to be quite within the capacity of local joiners, and there is very little employment of the more highly paid millwright. Cleaning machinery is still behind the times, and the more specialised equipment found in flour mills is slow in reaching the farm. A new American separator designed for farm use is being tried at three centres this season. This machine, which classifies grain by the length of each berry, instead of by width as does a sieve, will make such a separation as 30 per cent. top or seed corn, 60 per cent. normal grain and 10 per cent. poultry and broken grain and seeds, though the proportions can be readily altered to meet the needs of a sample. This type of machine has long been used in maltings, where the removal of the last broken grain of barley is essential, since broken grains go mouldy and may taint a whole braird.

In the last few years a very much larger proportion of English grain has come on to the market after harvest, and doubts have been expressed as to the consequences if this practice extends. It is curious how little organised marketing of wheat there is in this country compared with others, and it has been suggested recently that the time is ripe for some further action to be taken about this under the powers we now have from the Marketing Act. One of the main reasons why English wheat is so unpopular with flour millers is the difficulty they have in buying large parcels of uniform quality. In the great grain-growing areas of the world, the small farmers almost invariably have some form of co-operative

organisation which will accept, clean, grade and blend and store their grain—in parts of Minnesota, Wisconsin and Ohio these small co-operative elevators may be seen at every wayside railway station. Could we not do something on these lines to encourage production in this country ? The storage capacity of the small country mills is inadequate, and the business of provender making, to which they have been forced by the competition of the great port mills, absorbs most of their bin space. Co-operative granaries, erected with the help of a Government subvention, would enormously increase the storage capacity of the country : they would smooth out fluctuations in grain prices, and would provide a useful reserve against conditions of national emergency. From the farmer's point of view, they would remove from his shoulders the tedious business of selling his crops, get him a better price, even in these days of quotas, and leave him free to attend to his cultivations. And perhaps, since the conversion of British wheat into bread is not an impossibility, it might, after many years, be possible for our town dwellers to purchase a loaf in which British flour was not a minor percentage.

SCOTTISH AGRICULTURE IN THE CENSUS

JOSEPH F. DUNCAN

FOR Census purposes the Registrar divides industry into twenty-two orders, and Agriculture in Scotland occupies fourth place in the list according to the number of people engaged. The first three places are taken by Commerce and Finance, Manufacture of Metals and Machines, and Personal Service, in that order. It can be very reasonably argued that Agriculture is a more homogeneous industry than any of these three categories, and that it is still entitled to be regarded as our largest single industry. It includes 12·6 per cent. of all occupied persons in Scotland. It may be of interest, then, to consider what the recent Report on the Occupations and Industries of Scotland shows as to the position of the industry, and how it stood in relation to industry as a whole when the Census was taken in April 1931.

The first point of interest is to find how it stood as compared with 1921. I propose to confine myself to that side of the agricultural industry which might more properly be considered as the Farming Industry, and to exclude Estate Management and Forestry. Besides the ordinary crop and stock farming, there is included market gardening, nurseries, fruit- and flower-growing. This gives, I think, a better view of the commercial use of land. A note of warning is necessary as to the figures used. They are the figures for those engaged in the industry as I have defined it, and not the occupation figures.

The following table shows the numbers in the principal categories for the last two Censuses :

	1921		1931	
	Males	Females	Males	Females
Farmers	30,807	2,249	31,407	2,347
Farmers' Relatives	3,699	969	10,273	1,147
Grieves, Foremen	5,016	10	4,572	..
Shepherds	7,232	15	7,830	..
Farm Servants—				
In charge of Cattle	10,733	4,012	12,699	..
In charge of Horses	36,915	..	21,979	..
Not Distinguished	25,431	9,836	28,077	5,573
Dairymaids		..		2,571
Crofters	14,573	2,500	10,390	1,536
Crofters' Relatives	2,238	1,426	2,138	351
Gardeners, Nurserymen	5,607	339	3,827	265
Gardeners' Labourers	1,492	763	1,352	476

The outstanding fact about these figures is the continued decline in the number of women employed. There is a decrease of almost one-third during the ten years. Some of the other changes are more difficult to account for. A 25 per cent. decrease on the number of crofters can hardly be accounted for by some of them having returned themselves as farmers as the Registrar suggests. The changes shown in the numbers of male farm-servants show a net decrease of 10,324 for the period, but this must be set against the increase in the number of male relatives of farmers, which amounts to 6,574. The total figures are more important than the figures in the respective classifications. It is difficult to believe that there is one cattleman for every two horsemen in Scotland, or that there are four men at orra work, or labouring, for every three horsemen. The likelihood is that a considerable number of men in charge of horses is included among the "Not Distinguished." According to the Agricultural Returns for 1931 there were 117,221 horses used for agricultural purposes, and for that number 22,000 hired men is too small an allowance. How many of the increased number of 6,574 farmers' relatives employed on the farms may be due to a difference in the filling up of the forms we have no means of knowing. It seems a startling change, but we have to remember that the Census of 1921 was taken at the close of a period of unexampled high profits for farmers, when they could afford to give their sons a fairly free hand. The situation in 1931 was such as to induce every farmer who could replace a hired man by a relative to do so.

The 1931 Census shows the numbers of persons returned as out of work at the date of the Census. The tables for the industrial groups do not give the numbers of the different classes of workers returned as out of work ; these are given in the tables of occupations, but the numbers are sufficiently near that it will be quite safe to

assume they are the same for the industrial groups. They show that the percentages out of work were grieves and foremen 1·5, shepherds 3, cattlemen 2, horsemen 2, and "Not Distinguished" 11; or 5·7 for the whole group of wage-earners. Amongst women wage-earners the byre-women showed 2·4 per cent. and "Not Distinguished" 11 per cent.; or 8·2 per cent. for the whole group. This is the first and only occasion on which we have had a reliable record of the number of farm workers out of work, and the actual figures exceed any of the estimates that were made about that time. In view of the date of the Census (26th April 1931), one of the busiest seasons of the year, we have to face an entirely new situation in rural Scotland as far as employment is concerned. There is no longer work for everyone who is willing to accept it. The tables showing the distribution of those out of work according to age groups show that the incidence, as one would expect, is highest in the age groups from 45 onwards.

There is an interesting table showing the percentage in each industrial status for the Industry Orders. Those engaged in the industries are ranged in four status groups: Managerial, Operative, Own Account and Out of Work. Managerial includes employers, directors or managers, while the Operatives may be taken as approximating to the wage-earners and small-salaried section of the employed population. How the Agriculture Order (which includes Estate Management and Forestry) compares with All Industries is shown by the following figures:

	Managerial	Operative	Own Account	Out of Work Males	Out of Work Females
All Industries . .	5·5	73·2	5·2	18·2	11·1
Agriculture . . .	16·4	65·9	13·0	4·6	5·3

Agriculture has the highest percentage of all industries in the Managerial status and is third highest in the status "Own Account," being exceeded by Fishermen and Clothing Manufacture. It is the lowest for "Out of Work" except for the Professions Order.

It is interesting to pursue this analysis further for the Farming Group, that is excluding Estate Management and Forestry, and to find how it compares with the average for the whole of industry and for certain of the larger industries. The following table shows how the Farming Group compares with All Industries and with the Distributive Trades. I have selected the Distributive Trades because it is the only group which conforms to the same status grouping as Farming, yet shows some significant differences. The figures are for males. I have included "Out of Work" along with the "Operatives." This is not strictly accurate but the numbers for "Managerial" and "Own Account" are bound to be small, and they are not given for the different status categories. As the purpose is to show the broad trend in the Farming Group, and the same method is adopted for All Industries and for the Distributive

Trades, the comparative results are not likely to be affected by doing so. Unless the Out of Work persons are included in their status, comparisons would be invalidated.

The figures give the distribution in the different age groups per 1000 persons.

Age Groups

	TOTAL	14 and 15	16 and 17	18 to 20	21 to 24	25 to 29	30 to 34	35 to 44	45 to 54	55 to 59	60 to 64	65 to 69	70 and over
MANAGERIAL—													
All Industries .	66				2	4	6	15	18	8	7	4	4
Farming . .	187			1	2	8	14	36	46	25	21	16	18
Distributive .	138			1	3	9	13	33	36	17	12	8	6
OWN ACCOUNT—													
All Industries .	56			2	2	4	5	11	12	6	5	4	5
Farming . .	127			2	2	5	8	20	25	15	15	14	21
Distributive .	130			5	7	12	14	28	27	13	10	8	6
OPERATIVE—													
All Industries .	876	30	50	80	100	111	93	150	131	56	42	22	11
Farming . .	686	47	66	90	96	87	59	87	74	31	24	16	9
Distributive .	732	75	74	86	99	85	62	97	76	33	25	13	7
TOTALS—													
All Industries .	1000	30	50	82	104	119	104	176	161	70	54	30	20
Farming . .	1000	47	66	93	100	100	81	143	145	71	60	46	48
Distributive .	1000	75	74	92	109	106	89	158	139	63	47	29	19

The first thing that strikes one in considering this table is the proportion of males in agriculture of managerial status, but it is surprising to find it higher than in the Distributive Trades. It seems that about three-fourths of farmers are returned as being of managerial status, and about one-fourth as on "Own Account." That distribution would appear to be unduly high on the managerial side, but making every allowance for those working farmers who are included as managerial, it is clear that management is relatively much more burdensome on agriculture than on all other industries, even including the distributive trades.

But the most striking fact brought out by the table is the age distribution in farming. Most people will be astonished to find that farming runs the distributive trades hard for the premier position as a blind-alley occupation. The distributive trades are the worst offenders because they have a total of 202,073 males engaged as compared with 139,307 for farming. The only other industries which approach farming in the proportion of young people employed are the textiles and the manufacture of food, drink and tobacco, but their combined numbers for males engaged do not reach the total for farming, being 51,711 and 53,179 respectively.

If the age groups were more evenly spread than they are, the extent to which farming is dependent on juvenile labour would be more clearly seen. The peak for the largest number of males engaged is reached between 16 and 17. It then falls slightly to 18 to 20,

and then steeply to 30 to 34, and more steadily thereafter. The average for all industries shows the peak at 18 to 20 and remains fairly steady until 25 to 29, falling slowly thereafter. If we arrange the industries in three groups the peculiar position occupied by farming is brought out.

	Age Groups per 1000		
	14 to 20	21 to 54	54 and over
All Industries . .	162	664	174
Farming . . .	206	569	225
Distributive . .	241	601	158

The preponderance of message-boys comes out clearly in the distributive trades, but agriculture departs very strikingly from the average of other industries in the preponderance at both the earlier and the later ages. Little more than one-half the males engaged in agriculture are men in the most vigorous period of life.

If the full table given earlier is examined it will be found that in the Operative status, which corresponds to the wage-earning class, there is a very rapid and steady fall in the numbers employed from the age of 20 onwards. In the other two categories, Managerial and Own Account, the heavier figures fall in the latter years, but not enough to absorb the operatives for whom no place in the industry can be found. As long as other industries were expanding, and emigration was open to farm workers, the effect of this shrinkage in demand for adult workers was not felt, but in the conditions facing the country to-day the adult workers for whom farming cannot find places are not likely to be easily passed out to other occupations.

Nor is it a healthy state of affairs that entrance to positions of managerial responsibility or to occupation on one's own account should be more difficult for those engaged in farming until the later years in life. The Census figures show clearly one of the major difficulties of adapting farming to meet changing conditions. There is too great a preponderance of men at the older ages who are in a position to control the direction of the industry, who reach those positions after they have become set and are less likely to show the necessary enterprise and resiliency. The industry would be in a healthier condition if there were fewer inexperienced workers, and fewer old managers.

This distribution of the workers tells against the efficiency of the industry in various ways. The demand for young workers has the effect of making the rate of wages for boys relatively high compared with the rate for men in their prime, and that discourages the best of the workers from remaining in the industry. There is no call to incentive when the opportunity for continued employment in the industry so steadily declines with years and the opportunities of passing out of the operative class are postponed to the later years. It has to be remembered, too, that within the operative class

there are few grades and very little opportunity for improving one's position.

The Census tables do not show the age groupings for different areas of the country or for different farming conditions. We can, however, supplement the Census tables by turning to the Agricultural Returns for 1931, which give the numbers of workers employed on 4th June of that year in each of the counties, classified as those under 21 years of age, and those 21 years and over. The total number of male workers in the Agricultural Returns is given as 87,573 ; the total number of operatives in the farming group I have taken is 89,694. The totals conform as well as could be expected, but there is a greater divergence when we compare the groupings. The Agricultural Returns give the number under 21 as 20,992 while the Census Report shows 26,838. The Census returns are likely to be more accurate since the Agricultural Returns are filled in by occupiers who are hardly likely to make special inquiries as to the ages of workers. But for our purpose the Agricultural Returns will serve. If we take out the counties which show employment of young men above the average, we find they are the following : Aberdeen, Ayr, Banff, Bute, Caithness, Dumfries, Dunbarton, Kincardine, Kinross, Lanark, Moray, Orkney, Renfrew, Stirling, West Lothian, Wigtown, Zetland. These counties are either the dairy counties, or the counties in which the average size of holding is generally round the 60-acre figure. Employment of adolescent workers is therefore associated with dairying and small farming.

The popular policy in farming has been to increase the number of men working on their own account, in the hope that in that way the number of people working on the land would be increased. This would be secured if the opportunity of securing holdings were open to men while they were at the ages at which they are normally rearing families. An examination of the figures for those in farming who are working on their own account shows that 29 per cent. are under the age of 45 and 71 per cent. over that age. In the crofting counties this policy of land settlement has had time to work out. More than one-half the numbers returned as working on their own account are crofters, and we find that 21·2 per cent. are under 45 and 78·8 per cent. 45 and over. When we turn to Volume II of the Report of the Census, we find that in the table showing the populations of the counties, excluding the burghs, it is the crofting counties which show the largest decreases in the last ten years, and four of them, Bute, Orkney, Sutherland and Zetland, show an actual excess of deaths over births, the only counties which do so. The inclusion of Orkney, which has been the most prosperous small-farming community in Scotland, is significant. In pursuing the policy of land settlement sufficient account has not been taken of the increasing longevity of the population. Succession to a small-holding or croft in the great majority of cases would appear to be deferred until the

successor is past the normal age of parentage, as was pointed out by the Committee on Land Settlement in Scotland which reported in 1928.[1]

I suggest that a policy which aims at an increase in the number of people engaged in farming—and that policy is being widely advocated to-day—ought to have some regard to the economic and social results which will follow. An increase of population on the land would be most readily secured by increasing the number of smaller farms, and that as I have shown means an increase of adolescent workers, at the expense of workers in their prime. It means an undue weighting of those in positions to exercise direction at the older ages. That means that farming is not using sufficiently its labour force during the most productive and enterprising ages, and that cannot be sound economic policy. Nor would it be good social policy to lessen the opportunities for employment of men at the ages when they would normally be rearing families. A healthy rural social life could not be built up by relying on adolescent workers for one-half of whom no place could be found in the industry after 30 years of age. We can no longer rely on developing manufacturing and construction industries to take over those for whom farming cannot find a place as they grow older, nor can we expect emigration to carry off the surplus. The wiser social policy, and it would also be the soundest economics, would be to make more use of workers in their prime, and make less call upon the adolescents, and encourage the older men to rest from their labours.

THE DIFFUSION OF SCIENTIFIC KNOWLEDGE TO FARMERS—SCOTLAND[2]

ALEX. M'CALLUM, O.B.E., M.A., LL.B.

THE diffusion of knowledge to farmers is not a new problem in Scotland. More than two hundred years ago it was exercising the minds of progressive landlords and other public-spirited men. At that time Scottish farming was in a very backward state: little general advance had been made on medieval conditions, and during the "hungry years" at the end of the seventeenth and the beginning of the eighteenth centuries things were at their worst. When, therefore, after the Union of the Parliaments in 1707 intercourse with England became more frequent, Scots gentle-folk, visiting their southern compeers, were much impressed with the difference between the state of agriculture there and the conditions prevailing at home. The knowledge so gained led to numerous attempts at betterment. Leading members of the nobility and gentry demonstrated

[1] CD 3110, p. 27.
[2] Address delivered to Section M of the British Association at Aberdeen.

on their own estates the efficacy of enclosing, draining, and planting, and of improved methods in ploughing, fallowing, haymaking, vegetable-growing, and the like.

Foremost among these demonstrators, according to Wm. Mackintosh, was the Duchess of Gordon, who caused to be brought down to her husband's estates in the north-eastern part of the kingdom "English plows and skilful plowmen acquainted with fallowing—heretofore utterly unknown in Scotland."

Interest in the movement spread to all parts of the country, and in 1723 at a meeting held in Edinburgh there was formed "The Honourable the Society of Improvers in the Knowledge of Agriculture in Scotland." Its promotion was due to the observation "of how much the right husbandry and improvement of ground is neglected, partly through the want of skill of those who make a profession thereof, and partly through the want of due encouragement for making proper experiments."

The Society's methods of diffusing knowledge were simple and straightforward. They first of all decided that it would be useful and for the service of the country that proper rules and directions should be published for fallowing of ground and for sowing grass seeds, flax and hemp, and for dressing and preparing these fibres for manufacture. The gentlemen who were to prepare and put in writing their thoughts on these subjects were very wisely instructed "to use a familiar stile, such as the country farmers might easily understand, and to make the directions in the most circumstantial manner they could devise."

These rules and directions were issued in 1724 under the authority of the Preses, Mr Thomas Hope of Rankeillor, and all the copies were quickly sold.

In further procedure the Society appointed sub-committees to deal with different sections of agriculture, and these sub-committees were invited "to mark down their thoughts thereupon in writing to be revised by the main Committee of the Society." They were also "to correspond with the most intelligent in all the different customs of the nation concerning their different ways of managing their grounds, that what may be amiss may be corrected and what is profitable imitated." The members of the Society were also asked "to form small societies of gentlemen and farmers in their several counties."

In short, the Society and its branches were intended to make a survey of farming methods in order to discover the most efficient, and to spread the knowledge of these through the country. Landowners and farmers were invited to submit problems of land management or animal husbandry: these were considered by the appropriate sub-committees whose findings were reviewed by the ruling committee; and the considered findings were in due course communicated to the inquirers. Many of these cases are reported in the "Select Transactions" of the Society (1743), compiled by

the indefatigable Secretary, Robert Maxwell of Arkland, and others in a later publication of his, *The Practical Husbandman* (1757).

The subjects dealt with are many and varied. They include such diverse matters as the treatment of light, dry, barren, and stubborn soils, and of moss, bogland, and heath; the use of whins for cattle feed; the method of planting potatoes; the application of lime; directions for fattening cattle; the pickling of wheat against smut; grafting apple-trees; preserving eggs; killing rats; instructions for distillation of spirits, and several methods of preparing drams—the early eighteenth-century cocktail.

The Society did much good work for Scottish farming, but the enthusiasm of its founders was not maintained by their successors, and the Society ceased to exist about the time of the 'Forty-five Rebellion.

The Secretary, Robert Maxwell, was the keenest and most energetic of its members. In addition to the general activities of the Society he suggested other methods of diffusing agricultural knowledge. Thus in 1739 he put before the Society for the Propagation of Christian Knowledge in Scotland a scheme for the application of certain funds in their control to the financing of his own agricultural experiments at Cliftonhall, near Edinburgh, and to the instruction there of boys in the new principles of agriculture.

He was an inveterate experimenter, and his experiments so interfered with the commercial management of his farm that he eventually became bankrupt.

He nevertheless continued strong in the faith, and although another proposal of his for the establishment of a Chair or Lectureship in Agriculture at Edinburgh University also fell through, he himself, "without the patronage of any public body and encouraged by individuals only," gave public lectures in Edinburgh in 1756. These, possibly the first agricultural lectures given in Britain, were attended by many of the farmers and landowners of the district. Two of them are published in *The Practical Husbandman*.

Similar enthusiasm to that of Maxwell for the spread of agricultural knowledge among his countrymen characterised the inveterate old Jacobite, Wm. Mackintosh of Borlum, the author of the *Essay on Ways and Means of Enclosing, Planting, Fallowing, etc., Scotland, and that in Sixteen Years at farthest*, published in 1729, a curiously interesting and suggestive book in which the writer inveighs against short leases, yearly tenancies, and the feudal services of tenant to landlord as hindrances to progress: advocates strongly the enclosure of fields and the consolidation of individual holdings, and urges the educating of both landlord and farmer to make them receptive of new ideas. Like Maxwell, he presses for the establishment of Chairs of Agriculture at some of the Universities and he suggests a School or College of Agriculture to be staffed by men who had gained their knowledge from practical experience and not merely from books. Indeed he is so far in advance of his time that he wants to see agricultural teaching included in the

curriculum of ordinary schools. In an age of hide-bound classicism it is refreshing to find a man expressing views so modern as that skilful husbandmen and artisans are more useful to the nation than mediocre philosophers or scholars. He argues that agricultural instruction should not be confined to boys born to be farmers or farm-workers, but should be given to boys in all schools, public and private, and especially to the sons of noblemen and gentlemen who will later have estates in their trust.

It will be remembered that one of the suggestions made by the Society of Improvers was that small societies of gentlemen and farmers should be formed in their several counties. Perhaps consequent on that suggestion one such Society was formed. In 1730 a "Small Society of Farmers in Buchan" was instituted, and one of the methods of improvement they adopted was the straightforward one of trying to raise the average of farming by making known what they considered to be the best practice in the district. They accordingly published in 1735 a treatise entitled, "A True Method of treating Light Hazely Ground, or an Exact Relation of the Practice of Farmers in Buchan; containing rules for Infields, Outfields, Haughs, and Laighs."

The preface avers that the Essay contains nothing purely speculative, but is a "plain and genuine relation of our practice as we have learned from tradition and our own repeated experience, put into method to ease our memories and for the instruction of beginners." As such it gives a graphic picture of the old conditions and of the difficulties of keeping land clean before the introduction of green crops.

When the Society of Improvers came to an end there happened to be in Edinburgh a body known as the Select Society, a sort of philosophical discussion club, and in 1755 some of the members formed a new association which they called the Edinburgh Society for Encouraging Arts, Sciences, Manufactures, and Agriculture. Their method of encouragement was the distribution of awards—medals and money prizes—for activities in specified directions. So far as agriculture was concerned they offered awards for the best dissertation on vegetation and the principles of agriculture, the best invention in agriculture, the best stud stallion, the feeding of the biggest number of calves in a season, the best salt butter, the best cow milk cheese, the greatest quantity of potatoes marketed before 20th August, and so forth.

Here we have the competitive spirit called in to assist progress. The Society's parade of stallions in 1759 was the forerunner of our live-stock shows which, though they have not been an unmixed blessing, assuredly were of much service to agriculture in setting up standards of quality in farm live stock and inciting the stockman to take pride in his beasts.

Needless to say, the newer modes did not make their way without both active and passive resistance on the part of a peasantry set in

their old habits and dour by nature. It is related of a laird in these north-eastern parts—David Barclay of Mathers—an old soldier of Gustavus Adolphus, retired to his ancestral estate and converted to Quakerism, that finding repeated instructions of no avail, he overcame the obstinacy of one of his ploughmen by knocking him down with a cudgel; whereupon, though the weapon was carnal, this demonstration of power had the desired effect, and the ploughman became tractable and quiet as a lamb. In spite of its success in that instance one hesitates to recommend this method of inculcating agricultural knowledge for application in these less robust days.

The Edinburgh Society ceased to operate in 1765, but the work and influence of its members and their predecessors helped to bring about a remarkable advance in Scottish agriculture, some measure of which is afforded by the increase in agricultural rental from something like £822,000 in 1748 to £6,250,000 in 1813.

Another factor making for advance was the business methods of management introduced upon the many Highland estates which were confiscated as a consequence of the suppression of the 'Forty-five Rebellion. These measures were naturally not put into operation without causing much hardship and discontent; and indeed it was the restless state of the Highlands in the second half of the eighteenth century that led to the formation of an association whose aim was the amelioration of social and agricultural conditions in the Highlands. This was the Highland Society of Edinburgh, the first steps towards the institution of which were taken in 1784, and which obtained a Royal Charter in 1787. A later charter of 1834 changed the title to that now familiar to us—the Highland and Agricultural Society.

The Society from the first was active in promoting the diffusion of knowledge in various ways, notably by the award of premiums such as those for essays on agricultural subjects, for best crops of hay, turnips, potatoes, and flax, for commercial cattle, for dairy produce, for improvements in agricultural implements and machines, for land reclamation, drainage, and ploughing.

The Society also gave strong support to the movement for the institution of a Chair in Agriculture at Edinburgh, and this actually came about in 1790.

In the same year, curiously enough, the Fordyce Bequest was made to Marischal College, Aberdeen, with the object of establishing a lectureship in Agricultural Chemistry and Natural History; but the bequest did not take effect until 1840.

The year 1790 is further notable because in the course of it Sir John Sinclair sent out to every parish the questionnaire which made possible the publication, in the years between 1791 and 1799, of the *Old Statistical Account of Scotland*, a mine of information upon social life and industry in all parts of our country, and specially interesting in relation to farming. In that publication we have an outstanding example of the method of survey as intended to

stimulate improvement. The method had indeed been utilised previously, as *e.g.* when in 1773 the Commissioners for the Forfeited Estates invited an East Lothian farmer, Andrew Wight, to make surveys of these estates and of the north-eastern counties generally, and to put forward suggestions for betterment. But the *Statistical Account* was much wider in scope and more general in treatment, and it doubtless had a stimulating effect on many backward districts.

Sir John Sinclair made a gift of the property in the *Old Statistical Account* to the Society for the Sons and Daughters of the Clergy, and that Society, with the sanction of the General Assembly of the Church, carried through a second survey, again by means of reports from all the parish ministers, and these were embodied in the *New Statistical Account* published by Messrs Blackwood in 1845.

To digress for a moment, one may hazard the suggestion that the time is now ripe for a third survey. It seems a pity that, having two such excellent accounts of agricultural and social conditions, Scotland should not continue the series at intervals. The comparison of present-day conditions with those of a hundred, and a hundred and fifty years ago would be both interesting and instructive, and the record would be useful to future generations. Perhaps at the least a survey by counties might be undertaken, and so far as agricultural conditions are concerned, the staffs of the Agricultural Colleges could lend valuable assistance, and the Department of Agriculture might co-ordinate the whole.

This historical review has, one hopes, brought out the fact that the voluntary agencies mentioned therein had actually exploited most of the now familiar ways of spreading agricultural knowledge, viz.:

(*a*) Demonstration of more efficient methods.

(*b*) Advisory services.

(*c*) Publication of information in newspapers, books, and pamphlets.

(*d*) Lectures and lecture courses.

(*e*) Exhibitions of stock, etc., award of premiums, and other means of stimulating rivalry in improvement.

(*f*) Field experimental work.

But all this had been carried on more or less sporadically, and as time went on the need was recognised for regular, systematised, and sustained effort in these and other lines, and accordingly we arrive at the stage of the institution of instructional centres at Edinburgh and Aberdeen as already noted, and later of one at Glasgow. The story of the development of these schools of agriculture is interesting, but need not be dwelt upon now. Suffice it to say that the development followed the natural differentiation in the character of the farming in the three provinces, with some specialisation in crofting, cattle-rearing, and feeding in the north, arable

farming in the south-east, and dairying in the south-west; and with pastoral farming general in all parts.

Again, when the funds of the Development Commission were made available for financing research into problems connected with agriculture, our national preoccupation with animal husbandry brought it about that four out of the six research institutes set up in Scotland were devoted to animal problems. And here one may add that the importance of our fruit industry is now such that the addition of a research agency to deal with its problems seems called for. The conditions of our soil and climate necessitate research on special lines.

As it stands, however, our national organisation for education and research consists of:

I. Centres of instruction at Aberdeen, Edinburgh, and Glasgow, and attached to the last-named the Dairy and Poultry Schools at Auchincruive.

II. County work organisation.

III. Advisory Officer specialist Staffs attached to the Colleges.

IV. Research Institutes:

(i) Animal Nutrition .	The Rowett Research Institute.
(ii) Animal Breeding .	Animal Breeding Research Department, Edinburgh University.
(iii) Animal Diseases .	Animal Diseases Research Association.
(iv) Dairying . .	The Hannah Dairy Research Institute.
(v) Plant-Breeding .	Scottish Society for Research in Plant Breeding.
(vi) Soils . . .	The Macaulay Institute for Soil Research.

These agencies, with small specialist staffs at Edinburgh dealing with Farm Economics and Plant Pathology, the Seed Testing and Plant Registration Station, and the Statistical Section of the Department—all working under the general supervision of the Department of Agriculture for Scotland—constitute our organisation for the spread of scientific knowledge to the farmer.

How should it make contact with him?

As regards instruction at the centres, it is obvious that attendance at full courses in a university or college must always be confined to a small proportion of the farming community; but one hopes to find it producing the leaders in agricultural thought and practice—men receptive of new ideas and willing experimenters.

The main body of farmers must be reached in other ways.

Short courses at the centres are possible and will be most useful when they are most specialised and most intensive. Attempts to cover a wide field in four or five weeks are futile.

But the main responsibility for getting at the rank and file of farmers rests on the county agricultural staff. Here our system differs from the English organisation inasmuch as the Scottish county staffs are branches of the College organisation. Each College has about twelve counties allocated to it and the instructors in each College province are members of staff of the respective Colleges, not as in England where each county staff is a separate unit under its County Council.

The English system, through local responsibility and control, ensures local interest and local financial support. In Scotland the work suffers from lack of local interest, but, on the other hand, the close connection with the Central Institution and the support of its resources are helpful. An attempt has been made to stimulate local interest by the creation of County Joint Advisory Committees, but these are not likely to be really efficient unless some measure of responsibility is delegated to them by the County Councils.

It is unnecessary at this time to say anything about the duties of the County Officer as the mouthpiece of agricultural science to the farmer. The methods to be adopted have often been discussed, and the wise organiser will vary them according to circumstances and will utilise whatever means will bring him into closest touch with his clientele.

An onlooker at the game for a number of years may, however, offer a few observations by way of suggestion.

The post of County Instructor is one calling for so much ability, knowledge, wisdom, and tact that one would like to see it made attractive enough to draw to it the best of our scientific agricultural men. And they should not only have a first-rate training record in agricultural science, but they should have a full experience of practical farming in at least one of its branches. It should also be a *sine qua non* for appointment that a course of training in teaching method should have been taken. While advisory visits, consultations, and correspondence are bound to take up much of the time and energy of an officer who has gained the confidence of his constituents, he ought to guard against the risk of his coming to look on this contact with individuals as the whole duty of the County Organiser or Instructor. On the contrary, his main effort should be directed on the more general lines of the technical education of young people, and of practical demonstration work with field trials, feeding experiments, samples of farm management—of the small-holding type especially—and so on.

He will find it useful to make a careful study of his area, its agricultural practice and possibilities, and to record in writing his observations thereanent for his own future reference and guidance. And, as is intended in our Scottish system of organisation, he should make full use of the resources of the College and on occasion also of the Research Institutes.

As regards the staffs of these last institutions, while it is essential

that the research worker should maintain sufficient contact with practical agriculture to appreciate the farmer's point of view and his peculiar difficulties, at the same time his job is research and his time is not to be dissipated in passing on knowledge or advice to individuals. Accordingly the main contact of the farmer with research should be through the Colleges and their county staffs. And in order that this contact should be real and well-maintained, opportunity should be provided regularly for the College county man being made acquainted at first hand with the latest accomplishments of the research worker.

It may be said here appropriately that for really efficient contact to be made with working farmers throughout the country the present staff of county officials in Scotland is too small. In many cases the county areas are too wide and the numbers to be reached too great for even the most active and enthusiastic official to overtake all the work that should be carried out, and it would be well, when circumstances make this possible, if the county staffs were judiciously strengthened.

A possible development of our system is the adoption of the Danish and American idea of the advisory specialist, such as the pig-keeping expert, the adviser in sheep-management, or the consultant in poultry-keeping, or on potato-growing, and so forth. Any such officials would require to be recognised authorities on their subjects who would command the confidence of the industry, and their services should be available wherever required. But the responsibility for dealing with the farmers' problems in the first resort must remain with the general practitioner—the county man.

So far nothing has been said about special training for women, but a brief reference to this aspect of agricultural education must be made. In a region of small and moderate sized farms, such as are found in the north-east, the work and influence of the woman are all-important. Indeed it is not too much to say that not only the comfort and well-being of the family, but also much of the outcome of the farm operations depend upon her. Special training for her multifarious duties and responsibilities is obviously called for, and while in similar circumstances several continental countries, notably Belgium, have provided for it handsomely, we in Britain have been slow to recognise the need.

It is therefore the more gratifying to be able to call attention to an Aberdeen institution—the Craibstone School of Rural Domestic Economy—whose aim is to provide just such a training as will be helpful to the woman on the small farm. In providing that training it is rendering a service of incalculable benefit to the rural community and to the nation.

MILK MARKETING IN NORWAY

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Development of the Dairy Industry.—At the middle of last century there were dairies on individual large farms in Norway similar to the estate farm dairies in Denmark, but these were for the handling of the individual farm's own milk and were strictly private. In addition, there were very few of these large farms, and the dairies at that time were therefore of very little significance. The first dairy for the joint handling of the milk from several farms was *Rausjödal*, established in 1855. In this, it is interesting to note, Norway preceded most other countries. It was not until 1863 that the first dairy for handling milk from several farms was set up in Denmark, and that dairy was a privately owned concern. The history of the Danish co-operative creameries dates from 1882. Long before this, however, the joint handling of milk was a common practice in Switzerland. From the thirteenth century it has been customary in that country for a number of neighbouring farmers to club together and handle each other's milk in turn, the object being to have a larger quantity of milk each time and consequently more economical production of cheese. It was not until 1815, however, that the first co-operative cheese factory was set up in Switzerland. In North America the first co-operative dairy was established in 1851. England came later—in 1889.

Norway's first "co-operative" dairy—*Rausjödal*—was in form an ordinary joint-stock company, but in its organisation it was co-operative in that the stock, the liability and the income were divided on a per-cow basis. It was a *seter* or mountain cheese dairy, operating only during the summer months, and might have succeeded as a business enterprise had it not been for two very formidable difficulties. The cheese manufactured had to be transported by horse and cart, the only means of transport then available, over a distance of approximately 100 miles (statute) of rough mountain roads to Trondheim, the nearest market. As a result, a large proportion of the cheese was often damaged before it was sold. The second—and perhaps more important—difficulty was that the per-cow basis of apportioning the income gave rise to a great deal of enmity and jealousy resulting in continual bickering and squabbling, not so much among the farmers themselves as among their wives. This, on top of the business difficulties, caused the dairy to be closed down after it had operated only two summers.

The *Rausjödal* example was followed by the setting up of other dairies in the next few years. The organisations formed were not strictly co-operative, in fact they were formally joint-stock companies, but all had as their main object not the return of earnings on capital invested, but the payment of as much as possible for the

milk delivered by the members. There was a rapid development of the dairy industry in the Eastland in the sixties, Tröndelag followed in the seventies, then the Westland in the eighties, and finally Northern Norway in the late nineties. The development in this order was, in part, a reflection of the relative degrees of advancement in agriculture in general in the different regions of the country, but to a greater extent it was due to personalities—far-seeing farmers and others interested in the progress of farming in general and of dairying in particular. Available transport facilities also exerted an influence—a hindering one. Then, as now, these were best in the Eastland, better in Tröndelag than in the Westland, and worst in the northern part of the country.

The following figures, showing the number of dairies and the milk received from 1875 to 1930, briefly indicate the development of the dairy industry.

Year	No. of Dairies	Milk received (000 kg.)	Milk received per dairy (000 kg.)	(000 galls.)	Index
1875	106	16,739	158	34	100
1890	307	77,278	250	53	156
1900	845	184,024	220	47	138
1910	742	277,765	370	79	232
1915	698	304,807	430	92	271
1920	552	281,434	510	109	321
1925	602	351,869	580	124	365
1930	643	427,676	670	143	421

The decrease in the number of dairies after 1900 was not so much due to the failure of individual enterprises as to the combination of enterprises for more economic working. Since that date there has been a strong movement towards centralisation as is indicated by the figures for milk received per dairy, only a small part of the increase being due to expanding milk production in the country. The following figures, showing the number of dairies in different size groups, according to the milk received in 1910, 1920 and 1930, clearly indicate this tendency towards greater centralisation in the industry.

Size group (000 kg.)	1910	1920	1930
under 100	310	116	129
100– 200	247	106	100
200– 500	207	187	188
500–1000	47	86	128
1000–2000	7	34	53
2000 and over	7	23	44

In the last few years the number of dairies handling less than 100,000 kg. (21,300 gallons) of milk annually has been on the

increase due to the setting up of new dairies of the *seter* or mountain type, all of which fall into this group. Otherwise the number of dairies handling less than half a million kg. (106,000 gallons) annually has been decreasing, while the number receiving more than that quantity has been increasing. There are still too many small plants, however, and working expenses are consequently higher than they might be. The tendency is definitely towards greater and greater centralisation, but the movement is greatly handicapped by lack of adequate transport facilities. Compared with other Scandinavian countries the milk handled per dairy in Norway is a very small quantity. The Norwegian average for 1930 was only 670,000 kg. (143,000 gallons), while that for the Danish creameries in the same year was no less than 3,490,000 kg. (745,000 gallons). The corresponding figure for Sweden in 1929 was 1,200,000 kg. (256,000 gallons), and for Finland in 1928, 870,000 kg. (186,000 gallons).

Milk Production and Utilisation.—Despite the great development of the dairy industry in Norway only about 35 per cent. of the total milk production, estimated at 1,236 million kg. (264 million gallons) in 1930, passes through the dairies. Excluding loss and wastage and milk fed to stock on the farms, the proportion sold through the dairies is about 43 per cent. The following calculation, based upon the official statistics, shows the utilisation of the total milk production in 1930.

	Million kg.	Million gallons	Per cent.
Sold through the dairies	427	91·2	35
Home consumption on, and direct sales from, farm	587	125·4	47
Used for feeding (calves, etc.) on the farm .	160	34·2	13
Loss and wastage	62	13·2	5
Totals . .	1,236	264·0	100

Of the 35 per cent. passing through the dairies in 1930, 46·5 per cent. was sold for liquid consumption, 26·7 per cent. went to cheese-making, and the remaining 26·8 per cent. to butter-making. In the early days of the industry butter-making was the most important outlet, at one time absorbing two-thirds of the milk handled by the dairies, but up to about 1920 this outlet gradually diminished while the proportion going to liquid consumption steadily increased. The percentage going to cheese-making remained fairly steady up to 1915, but between 1915 and 1920 the former proportion was almost doubled. Between 1920 and 1925 the percentage finding a liquid outlet fell off considerably, that going to cheese-making increased, while, for the first time since the early days of the industry, the proportion manufactured into

butter showed a definite increase. The following figures illustrate the trends since 1875.

Year	Percentage of Milk received used for Butter-making	Cheese-making	Liquid consumption
1875	66·2	8·8	25·0
1890	63·6	6·4	30·0
1900	53·9	7·5	38·6
1910	38·7	7·1	54·2
1915	28·4	9·7	61·9
1920	12·2	18·0	69·8
1925	23·4	25·5	51·1
1930	26·8	26·7	46·5

It may be noted that the decrease in the proportion going to liquid consumption in recent years is not attributed to a falling off in the consumption of milk but to the increase in production in the post-war period. The utilisation of the milk passing through the dairies is, as might be expected, largely dependent upon the relative prices of butter and cheese, and primarily, of course, upon the extent of the liquid market.

In this connection it is interesting to note the distribution of the dairies according to type. In the following table at least 90 per cent. of the milk handled must go to one outlet before a dairy can be placed in any group other than "mixed production."

	1920	1925	1927	1928	1929	1930
Milk sale	65	51	71	75	74	63
Collecting depots	219	244	216	207	196	208
Butter dairies	44	49	55	63	62	59
Mountain dairies (cheese)	..	6	9	31	41	34
Butter and Cheese	46	63	22	26	23	20
Making old types of cheese	6	14	19	16	13	13
Full cream cheese	47	39	28	24	18	14
Skim milk cheese	18	35	40	42	39	37
Mixed production	100	96	149	156	180	191
Condensing factories	5	5	5	5	4	4
Totals	550	602	614	645	650	643

The outstanding point is the large increase in the number of dairies with mixed production—from 100 or 18·2 per cent. of the total in 1920 to 191 or 27·9 per cent. of the total in 1930. Generally speaking the tendency is towards diversification rather than specialisation. This may be attributed, at least in part, to lack of adequate and cheap transport, a large number of the dairies being compelled to manufacture butter and different types of cheese to satisfy local requirements.

Payment for the Milk.—The pooling system, after making allowances for differences in the quality of the milk, is generally used by

the dairies. It is only within comparatively recent years, however, that payment according to quality has become general. In 1925 only about half the dairies tested the fat-content of the milk received and paid for it accordingly, but by 1930 the proportion doing so had increased to 78 per cent. A few now use the Reductase test in conjunction with the fat-content as the basis for payment. Altogether 85 per cent. of the dairies in 1930 conducted regular fat-content tests and 23 per cent. Reductase tests. Even at the present time, however, about one-fifth of the dairies still pay a flat rate for the milk received, irrespective of its quality. This is rather surprising when over 50 per cent. of the milk is manufactured and when the output of butter and cheese is in direct proportion to the butter-fat content.

Ownership and Form of Organisation.—It is characteristic of the Norwegian dairy industry that the producers themselves, ever since the business gained a foothold in the country, have owned and managed most of the dairies. Private dairies have always been few, and so also leased dairies. At present about 90 per cent. are owned and run by the milk producers.

The early dairies were, as already mentioned, formally joint-stock companies, but when co-operation as a form of business became generally known, most of the new dairy organisations were set up as true co-operative enterprises. In later years some of the older joint-stock dairies have changed their form of organisation so as to become formally co-operative. This reorganisation has met with considerable difficulties of a formal nature and there are still quite a number of dairies which are joint-stock companies in name but are run along co-operative lines. There is scarcely any difference between these and the true co-operative dairies, and for all practical purposes all the dairy plants which are operated by the milk producers can be reckoned as co-operative enterprises.

In the voting the one-man one-vote principle is generally adhered to but there are exceptions, voting power in some cases being in accordance with the number of shares held. The new model by-laws allow the basing of the right to vote on the number of shares held whereby one member can have up to three votes as follows: 1 to 5 shares, 1 vote; 6 to 15 shares, 2 votes; and 16 or more shares, 3 votes. This system is an attempt to steer an intermediate course between the one-man one-vote principle and the basing of voting power upon the quantities of milk delivered. In this respect they are departing from recognised co-operative principles.

Previous Federation.—In the early days of the dairy industry the local enterprises were strictly independent and competed one with the other. It was not until 1881 that the first general organisation—the Norwegian Dairy Society (*Den Norske Meieriforening*)—was formed, though there were district organisations previous to that date. The main object of this national society was to work for

the attainment of better marketing conditions for the country's dairy produce. At first its membership was composed of individual producers, dairies and local dairy societies, but in 1910 its by-laws were amended and it became to a greater extent a national union of local societies though it still retained individuals as members. In 1920 the name was changed to the National Union of Norwegian Milk Producers (*Den Norske Melkeprodusenters Landsforbund*) and individual membership was abolished. With the formation of the Milk Centrals it became necessary to have a federal organisation for these and the National Union of Norwegian Milk Producers undertook the functions of this central organisation. This it did in 1931 when the by-laws were amended so that the direct members of the Union became the Milk Centrals, or, where such did not then exist, the local dairy societies provided that their by-laws were approved by the Union.

In the early years of the present century some co-operative butter-exporting societies were formed, but the activities of these and subsequent societies ended when the export of butter ceased at the outbreak of the Great War. The present-day organisation for dealing with butter export will be dealt with later.

In the more important liquid markets there has been a certain amount of co-operation between the local dairies. The usual organisation to-day has one central plant within the liquid market for treating and distributing the milk, and collecting depots throughout the district concerned which collect the milk, cool it and send it to the central plant. The oldest and largest of these organisations is the Oslo Milk Supply Company, which has about 80 dairies and collecting depots within a comparatively small radius of Oslo. Among the latter some of the best plants are used as manufacturing dairies when the supply of milk exceeds the liquid demand. In the larger towns there are usually two or three co-operative organisations, and competition between these has not been wholly removed; in fact the competition is very acute in some places, more acute than it is between the co-operatives and the private companies.

Post-war Developments.—The first attempt after the War to form a more general organisation for the marketing of dairy products was made in 1921 when the establishment of a central marketing agency was discussed. Agreement could not be reached on the proposed plan, however, and similar attempts were made in the following years, but all were unsuccessful until 1928 when it was agreed to establish an export union (see later). When agreement had been reached on this point, the question of setting up milk centrals in the various districts was taken up the very next year.

The cause of these efforts to obtain organised marketing was the increasing keenness of competition between the liquid milk market and the milk used for manufacture. Before the War the milk market in Norway was such that the price of milk for liquid consumption was fixed according to the price of milk used for the

manufacture of butter and cheese, but after the War it was found possible to maintain the former at a higher level than the latter. The following average prices paid for milk by different types of dairies in the period 1925 to 1930 show the differences between the "liquid" and "manufacturing" prices.

	Öre per kg.	Index
Dairies selling milk for liquid consumption	22·8	100
Full cream cheese dairies . . .	15·7	69
Butter and cheese dairies . . .	15·4	68
Butter dairies	12·2	54

Towards the end of the twenties there was a rapid falling off in the price of milk used for manufacture, and the more outlying dairies began to take an interest in the liquid market. Also, individual producers near the consuming centres began to break away from their local co-operative dairies and enter the liquid market independently. Improved means of transport enabled the more distant dairies to enter the liquid market and obtain a higher net return than from manufacturing the milk, and the larger the individual dairies became, the greater became the competition for the town markets as the prices of butter and cheese continued to fall. The proposed central marketing agency had no means of solving the problem, its activities being confined to the co-operative marketing of butter and cheese, and that was probably why the plan to establish it did not receive sufficient support.

The competition for the liquid trade became more and more acute. Price-cutting was rampant and in many places there were veritable milk wars. The liquid milk price fell considerably and it became obvious that, unless something were done to regulate the supply to the liquid market, it would soon fall to the level of that for milk used for manufacture. It was realised that, with proper marketing organisation, the price of the former could be kept above that for milk used for butter and cheese-making, and in the autumn of 1929 a committee was appointed to investigate matters and to prepare a plan for organised marketing. The New York Dairymen's League and the Scottish Milk Agency, Ltd. were the two organisations upon which the committee modelled its scheme.

The Milk Centrals.—The plan proposed was that each dairy or local organisation should retain its individual management as before but be subject to limited interference by the central organisation of the district—the Milk Central, one of whose functions would be to adjust the milk price so that all producers within its area or zone would receive the same basic price for their milk irrespective of its destination or utilisation. Seven zones were proposed, each being a geographical region having a fairly well-defined main liquid market, and with slight modifications the plan was enthusiastically adopted throughout the country. On account of disagreement in one of the

zones it was split in two and two independent organisations were formed. Eight Milk Central organisations, embracing the whole country in eight zones, were established in the years 1930 and 1931. Since then they have federated into the National Union of Norwegian Milk Producers mentioned previously.

The stipulation governing the formation of the Milk Centrals as regards control of production and marketing was that the organisations should have control in their respective zones of 80 per cent. of the milk marketed through dairy plants. This included milk marketed by producer-retailers in all places where these competed with the local dairies, but not the sales of non-competing producer-retailers in outlying districts. As the latter were small, it may be assumed that the actual control necessary was just under 80 per cent. of the marketed milk. In all cases the Centrals now have over 80 per cent. control in the formerly competitive fields in their respective regions.

The main tasks of the new organisations are (*a*) to regulate the marketing of milk for liquid consumption in such a way that its price can be maintained at a sufficiently high level above that of milk used for manufacture, and (*b*) to regulate the production of milk products and organise the marketing of these, and to a certain extent the export also so as always to keep the protective import duty on dairy products effective. The first of these tasks is carried out by the Milk Centrals themselves, the second by the Centrals working co-operatively with the Export Union. The organisations have State backing (not financial) in the Agricultural Marketing Act of 1930 and as amended in 1931. The Department of Agriculture have elected a Marketing Board as the official organ for carrying out arrangements approved under the Marketing Act.

Organisation of the Milk Centrals.—The two main points in the organisation are : (1) the producers contract to deliver to the dairy or collecting depot determined by the Central all their whole milk not required on the farm (the Central does not concern itself with the technical handling of the milk), and (2) the Central receives the income from all sales and apportions it between the members according to the rules. The producers receive a basic price which is fixed by the Central and is irrespective of the final destination or utilisation of the milk. The final price they receive depends partly on their geographical position and partly on the efficiency of running the dairy to which they send their milk. According as this efficiency is better or worse than the normal standard agreed upon, the producer receives a higher or lower price than the basic price fixed by the Central.

For price-levelling or price-adjusting purposes there is levied a fee on all milk sold for liquid consumption. Producer-retailers pay a fee to the Central either per litre of milk sold or per cow, this levy being calculated so as to equal the fee levied on milk sold through the dairies for liquid consumption. In some districts it was difficult

to get sufficient support to establish the Centrals, especially from among the producer-retailers who continued to give rise to difficulties even after the Centrals were formed. Their unwillingness to pay the price-adjusting levy was met by the State amending the Agricultural Marketing Act of 1930 in June 1931. Under the amendment there is now laid upon all milk sold for liquid consumption a compulsory adjustment levy whether or not the producer is a member of the Milk Central of the area, provided that there is an organisation of producers and dairies which represents the majority of the milk producers in that district (that is, producers whose productive capacity is about 80 per cent. of the marketed milk), and provided that the said organisation has imposed upon its members a levy for price-adjusting purposes on milk sold for liquid consumption. The Marketing Board's sanction must be obtained in fixing the size of the levy which is collected by the Milk Central of the area in which the milk is sold. The Board is empowered to enforce payment if necessary.

Besides the price-adjusting levy there is the marketing fee, which is imposed under the amended Agricultural Marketing Act for one year at a time on all milk sold, whether for liquid consumption or for manufacture. The sum derived from this fee is used for the purpose of improving the marketing of dairy produce in general, the administration of the money being in the hands of the Marketing Board and the National Union of Norwegian Milk Producers conjointly.

The Eastland Milk Central.—The Milk Centrals are all very similar in organisation and method of operating, and for purposes of illustration the Eastland Milk Central will be considered. The zone covered by this organisation is the six Eastern and South-Eastern counties (Östfold, Akershus, Hedmark, Opland, Buskerud and Vestfold) in which the main liquid market is Oslo. Its aims are few but stupendous and idealistic, namely : (1) to handle and market its members' milk ; (2) to rationalise the marketing of dairy produce; and (3) to regulate and stabilise prices. To what extent it has attained its objects will be considered later.

The membership of the Central is direct, but producers who are members of a dairy or other society of milk producers can join collectively through their organisation. In 1932 the membership embraced 243 dairies having about 24,000 producers, about 200 milk shops selling milk from some 2,000 farmers, and producer-retailers to the number of about 1,500, giving a total of some 27,500 milk producers. Only about 1,500 producers in this zone remain outside the organisation, and these produce only between 2 and 3 per cent. of the marketed milk. The membership contract is for three years in the first place, but at the expiry of that period any member can withdraw at any time by giving three months' notice. Members who withdraw are not paid for their share of the Central's property. The contract is very brief and simple, consisting merely

of a statement of joining as a member of the Central in accordance with its by-laws and an undertaking to obey and uphold all orders, rules and regulations lawfully issued by the Central. The members are divided into local societies or circles according to the Central's direction. In general these societies comprise a geographical or a delivery district.

Producer-retailers are obliged to send to the Central a report of their sales of milk, and are prohibited from selling milk at prices below the minimum fixed by the Central. In return the Central makes provision for handling any surplus which these producers may have. Shopkeepers are joined to the Central by annual contracts, and by these they can only take milk from the Central's members. The Central also decides what margin they may have for handling and selling the milk. For the other members—the ordinary producers—all sales of milk must be made at the place, at the price, and according to the rules laid down by the Central.

In administration the highest authority is the Annual Meeting of the Board of Management of the Central, the Committee of Representatives, and delegates from the local producers' societies, one delegate being chosen for each million kg. of milk delivered by the members in the course of the preceding year. Each member in the Annual Meeting has one vote. The Committee of Representatives has twenty-five members chosen by county—in such a way that they also form the management of the milk producers' societies in the counties concerned. This body must meet at least twice a year. The Board of Management consists of six members who are selected by the Annual Meeting, which also decides upon their financial remuneration.

Price Adjustment.—The basis of the price adjustment or price levelling is that all producers who do not enter the liquid market are paid an indemnity for keeping out of that market, the sum paid to them being derived from fees levied from those producers who take an active part in the sale of milk for liquid consumption. This, however, does not apply to milk used for butter and cheese-making on the farm, nor to milk manufactured in the mountain dairies, nor to the surplus milk of producer-retailers and of producers delivering to retailers, irrespective of whether or not these producers are members of the Central. There are, however, a few exceptions to this rule. The reasons for the exclusion of the mountain dairies are worthy of note. Most of these—the mountain dairies—embrace only a few producers, many only two or three, and if these were to be allowed the indemnity for taking no part in the liquid trade, the question would arise as to whether individual producers should get it. Were that allowed it would open up a field over which there would be no control. The mountain dairies operate only during the summer months, and in winter the producers send their milk to the manufacturing dairies in the valleys, and for the quantity sent they receive the price-adjusting indemnity. They

have the option of sending their milk to the valley creameries all the year round but they prefer to manufacture cheese in their own plants during the summer months, the net return for the milk being higher. These producers are therefore treated generously for they receive the indemnity in winter when it is impossible to operate their own dairies, and in summer they are allowed to take advantage of the higher profits accruing from their particular type of cheese-making.

The members of the committee which worked out the basic rules for the price adjusting unanimously agreed that the basis should not be the actual prices received by the dairies for milk and milk products, as that would be harmful to the good dairies and favourable to the bad, but should be based upon normal prices, that is, prices which could be obtained from normal output and management, and according to the net price which milk could fetch in its different uses under existing price conditions. Normal prices for milk going to different destinations have to be calculated, but this is a purely technical-economic question and must not be confused with the meaning which one otherwise attaches to the term "price adjustment." For purposes of calculating net prices the Eastland Milk Central considers the following classes :

(1) whole milk,
(2) cream (17-18 per cent.),
(3) "double" cream (30-32 per cent.),
(4) skim milk,
(5) milk for butter and cheese production,
and (6) milk for condensing.

In the first four groups the net prices are fixed by deducting from the retail prices the marketing margins allowed by the Central. That for milk used for the manufacture of butter and cheese is calculated on what is considered to be normal production from it in the dairies and the average butter and cheese prices realised during the preceding month. Similarly for milk used for condensing.

The book-keeping of the Central is in part best illustrated by an example. In a certain month a dairy received 522,693 litres of milk and, from information on the utilisation of the milk given in its monthly report to the Central, was debited according to the following calculation:

				Kr.
40,592	ltr.	whole milk @ 19·6 öre	per ltr.	7956·03
5,014	,,	cream @ 82·0 öre	,,	4111·48
384	,,	"double" cream @ 144 öre	,,	552·96
23,128	,,	skim milk @ 3·0 öre	,,	693·84
69,118				13314·31
2,074	,,	loss (3 per cent.)		
451,501	,,	to manufacture @ 9·8 öre	,,	44247·10
		The dairy is debited for the sum		Kr. 57561·41

and the Central credited for the same amount. Similar calculations are made for all the dairies and the total debit entries plus the fees levied from the retailers and the producer-retailers form the Central's gross income. From this is deducted a certain sum to cover administrative expenses (0·08 öre per litre in 1931), a contribution (1 per cent.) to the reserve fund, and 0·25 öre per litre as the marketing fee. The remainder is the members' joint property and is divided among them according to fixed rules. The Central credits the individual dairies with their turnovers of milk at the basic prices which it decides upon, and they can then pay the producer the normal basic price fixed by the Central if they have been operated normally and have had a normal output. If the efficiency of operating has been better than normal they are in a position to pay more, but if not so good they must pay less. The individuality of the dairies is therefore maintained. Theoretically the Central handles all the proceeds from the sale of milk and milk products in the zone, but actually it handles only the sums necessary for price-adjusting purposes, the contributions to the reserve fund, the marketing fees, and a sum to cover its own expenses.

The Basic Prices.—There are two basic principles in the calculation of the basic prices for the different districts. The first is that the prices shall be independent of the utilisation of the milk but must be fixed according to the place of production, and the second is that the starting-point for fixing the differences between the prices in the different districts shall be the costs of marketing the milk, the differences in which are mainly due to the distance from the market. In the Eastland zone there is no doubt as to which liquid market the distance is to be reckoned from, as Oslo is by far the largest, consuming as it does about half of the milk sold for liquid consumption in the area. Actually the principle followed is that the prices allotted to the individual dairies throughout the whole region (with a few exceptions) are the same as though these dairies were connected with a dairy in Oslo. The calculation consists of determining a basic price for Oslo by taking into account the total income from the sale of milk and milk products by the dairies and the quantity handled, after which the price to be paid to the producers is this basic price less the freight expenses in transporting the milk to Oslo and the actual expenses of handling the milk at the country collecting depot. The basic price for any particular district is the Oslo basic price (fixed monthly), less the *normal* cost of handling the milk at the collecting depot and the freight charge to Oslo. Elaborate cost studies are made to arrive at the normal cost of handling milk at collecting depots of average size in the various districts. There is actually very little variation in this cost. Distance from the market is the most important factor in determining the differences in the district basic prices.

The difficulty of the dairies not all being of the same type is met by having three basic price groups which are as follows :

(*a*) The producers and dairies delivering their milk to Oslo receive the Oslo basic price.

(*b*) Manufacturing dairies not connected with an Oslo dairy have to bear a deduction equal to the freight to Oslo on all the milk handled, and, until recently, an additional deduction on their manufactured milk, that is, on that part of the milk which could be sent to new liquid markets. This extra deduction represented the cost which would have had to be incurred to enter the Oslo market. Under the ruling of the Central, such dairies were debarred from entering the Oslo market and this deduction was therefore gradually reduced and finally discontinued as from April 1933. The district basic price in this case is therefore

> the Oslo basic price,
> minus the freight charge to Oslo,
> minus the cost of handling at a collecting depot of average size in the same district.

(*c*) Dairies which have local liquid markets of considerable size have possibilities of their own and there is no danger of their encroaching on the Oslo market with what can be sold locally. For such dairies the freight deduction is reduced in accordance with the amount of milk sold liquid in the local market, in other words, they receive compensation to the extent of freight charge to Oslo on that part of their turnover which they would not send to Oslo even though there were no regulations to prevent them from doing so. The compensation factor is not calculated for individual dairies but for fairly big districts, generally counties. The district basic price in this case is therefore

> the Oslo basic price,
> minus the freight charge to Oslo on total turnover,
> minus the normal cost of handling,
> plus the compensation factor on local liquid sales.

Complications arise in practice through dairies falling under two basic price groups, and also by the fact that retail and wholesale business may be carried on in the same dairy.

The dairies submit reports to the Central at the close of every month and from these the Central computes on the one side the debit amounts and on the other side the quantities of milk within each basic price group. By successive tries it is then found how high the Oslo basic price can be, and the other basic prices are then fixed accordingly.

As experience is gained in the operation of the price-levelling system certain rules may have to be changed. Some have already been altered, for example, the method of calculating the price in basic price group (*b*) above. The differences between the Oslo basic price and the basic prices in the outlying districts have also been reduced in accordance with the decrease in the cost of transport.

The Central has a special committee to act as a permanent expert body to consider and advise upon what changes may from time to time be found necessary or advisable.

Disputes arising between the Central and its members are settled by an arbitration committee of three persons, two of whom are chosen by the two parties concerned, and the third by the Chief Justice.

The Other Milk Centrals.—*Telemark Milk Central* embraces the county of Telemark only, and is the nearest approach to a dairy central. Membership is indirect and the Central includes only those dairies which previously delivered milk to the town markets. The Board of Management is vested with great power. It can regulate the handling of the milk and determine how much is to be sold liquid by each dairy and how much is to be manufactured; in the latter it determines what proportions are to be used for the production of butter and the different kinds of cheese. The calculation of the basic prices here is based upon the actual financial results of the member dairies for every month. In this it differs from the Eastland organisation which fixes the basic prices according to previously calculated figures for normal output of products and normal expenses. The price adjusting is somewhat more marked than in the Eastland zone.

The East Agder and West Agder Milk Centrals embrace the counties of the same names. They are organised in the same way as the Telemark Central, the members being the dairies and the local milk producers' societies. The membership contract is for five years, whereas it is for three years in the other Centrals. A fee is levied on all milk sold for liquid consumption, and the sum raised by so doing is divided on the manufacturing milk at a flat rate per litre. The principle here is that a fixed fee is levied which can be used for price levelling, that is, the actual price adjusting is secondary to the fixed levy. In the Eastland Central the price adjusting is the primary factor. The results, however, are much the same.

The Westland Milk Central comprises the counties of Rogaland, Hordaland, and Sogn og Fjordane. It has direct membership of the milk producers, but members of the true co-operative dairies are joined collectively. The fee levied for price-levelling purposes here is 8 per cent. of the retail price of all milk sold for liquid consumption. The principle is different, but the amount is about the same as the fixed levies of the other Centrals. In the apportionment of the sum raised from the fee, the dairies are divided into groups so that milk manufactured within a liquid milk market area receives a larger contribution than milk manufactured in the outlying districts.

Möre Milk Central (counties of Nord-Möre and Sör-Möre) also has direct membership of the milk producers, but producers who are members of a dairy or other body with delivery contracts are

joined collectively with the management of the organisation concerned. The fee levied in this zone on milk sold for liquid consumption varies according to the retail price, and also according to the time of the year. In the apportionment the same method is used as is followed by the Westland Central.

Tröndelag Milk Central (counties of Nord-Tröndelag and Sör-Tröndelag) is organised and run along lines similar to those of the Eastland Milk Central. The price adjusting too is based upon very similar rules.

The Milk Central of Northern Norway embraces the three Northern counties, Nordland, Troms, and Finnmark. The membership is as in the Telemark Central, but otherwise the organisation is different from all the others. The Central is merely an office which receives reports concerning the use of the milk, levies fees and redistributes them according to the information obtained from the reports. The Central takes no part whatever in the working and management of the individual dairies and has no right to dispose of the members' milk. This difference is natural when one considers the difficulties in transport and communication—and therefore control—in the Northern part of Norway.

Organisation of the Supplies and Export of Dairy Products.—Before the War there was a considerable net export of butter from Norway, but there was a small net import of cheese. During the War years the export of butter ceased, and after the War the import of butter was nearly as large as the previous export. In the last few years, however, the export trade has been re-established, and now there is a considerable net export of both butter and cheese. The development of the foreign trade in dairy produce since before the War is illustrated by the following figures (000 kg.) :—

	(Net Export+, Net Import—)	
Year	Butter	Cheese
Av. 1909/13	+1003	– 106
1926	– 919	– 229
1927	–1128	– 254
1928	– 658	– 75
1929	– 71	+ 230
1930	– 581	+ 286
1931	+ 567	+1033
1932	+1060	+1374

Norway's export problem was that the little surplus butter and cheese production in the spring months prevented full benefit being derived from the protective duty on dairy products. With the object of improving matters the Export Union of Norwegian Dairy Societies was formed in 1928. This is a co-operative organisation with variable capital, variable membership and limited liability. Shares are held in the ratio of one for every 100,000 kg. of milk received in 1927, and one for every 100,000 kg. used for manufacture in the same year. The Union is affiliated to the National

Union of Norwegian Milk Producers by special contract. It contracts with a suitable number of dairies regarding the delivery of quantities of dairy products for export, and if insufficient is procured in this way the deficiency is made up from the dairies concerned in proportion to their previous deliveries.

The organisation began by dealing with export only, but has since extended its activities to include the regulation of all the inland marketing of butter and cheese. This is accomplished by exporting the surplus in the first place, and in the second by levelling out the seasonal variations in the supplies by means of cold storage. The National Union of Norwegian Milk Producers has undertaken to meet the expenses incurred by the Export Union in its work in regulating the inland marketing. As far as is possible these expenses are met from the sum derived from levying the marketing fee on all milk sold, whether for liquid consumption or for manufacture. The Milk Centrals also contribute to the costs of running the Export Union.

In 1931 Parliament enacted that the margarine factories be compelled to intermix a certain quantity of butter with the margarine produced, thereby easing the butter market to a considerable extent. The percentage to be intermixed varies according to the surplus of butter produced, and was as high as 7 per cent. in the beginning of 1933, but was then likely to be reduced as the home consumption of butter was increasing and the producton of milk was beginning to decrease.

To regulate the cheese supply so that the price of milk used for cheese-making can be held at the same level as when used for butter-making, the Milk Centrals required their member dairies to return as much as possible of the skim milk to the producers. Part of the sum derived from levying the price-adjusting fee is used to provide financial inducement by way of a bonus on every litre of skim milk returned to the farm. So far this has been successful in maintaining a price for cheese which gives about the same net return for the milk used as when used for the manufacture of butter. In addition, it has helped to keep the protective duty on cheese effective.

The membership contract of the Export Union is for three years in the first place, and thereafter withdrawal may be effected in any year by giving six months' notice of the intention to withdraw. The Union is directed by a Committee of Representatives and a Board of Management. The members of the former are chosen by county in the same way as the members of the Committee of Representatives of the Milk Centrals, the basis being one representative for a minimum of 100 shares, two for a minimum of 300 shares, three for a minimum of 600 shares, and thereafter an additional member for every full 300 shares. The Board of Management is chosen by the Committee of Representatives, and consists of five members.

Disputes arising between the Union and its members are settled by an arbitration committee of three members. Each of the parties concerned chooses one member, and the Board of Management of the National Union of Norwegian Milk Producers the third.

The Boards of Management of the National Union and of the Export Union together form a central committee, which decides upon all matters of common interest. This body also acts as the representative of the whole dairy industry in its dealings with the Marketing Board, and makes proposals to it as to the use of the sum raised by levying the marketing fee on all marketed milk.

Summary and Conclusion.—The general principles of the present system of co-operative milk marketing in Norway may be summarised as follows :

(*a*) The country is divided into eight geographical zones each of which contains a fairly well-defined main liquid market.

(*b*) In each of these zones there is a Milk Central which is a co-operative organisation of the milk producers, either directly or indirectly.

(*c*) The marketing of the milk is regulated by the Milk Centrals in their respective areas, and these also to a certain extent regulate the production of milk products.

(*d*) Normal prices to the producers, marketing margins to retailers and wholesalers, and retail prices are determined by the Centrals.

(*e*) The liquid market is kept from being flooded by levying fees on all milk sold for liquid consumption and paying compensation to the producers of milk used for manufacture for keeping out of the liquid market.

(*f*) The Milk Centrals are federated into the National Union of Norwegian Milk Producers.

(*g*) The Norwegian Dairy Export Union regulates the inland marketing of butter and cheese and looks after the country's export of these commodities.

(*h*) The system has State backing under the amended Agricultural Marketing Act which provides the official administrative organ—the Agricultural Marketing Board.

The system has not been equally successful in all eight zones. The Eastland organisation has attained greatest success, partly on account of its having the main liquid market of the country within its area, but perhaps mainly because the enthusiastic proposers of the scheme have given most of their services to this organisation. Since it began its activities it has handled and marketed its members' milk in such a way that the prices paid to the producers have been much higher than they would have been if there had been no Milk Central or similar organisation. On that point there is no doubt whatever. Further, this Central has attained no small measure of success in its aim to regulate and

stabilise prices as is evidenced by the fact that extreme fluctuations in the prices for milk and dairy products are now non-existent. In addition, it has to a certain extent succeeded in rationalising the marketing of milk and dairy products within its area.

Considering the system in general, the most commendable point is the price levelling to remove the incentive to rush the milk on to the liquid market. The actual method adopted to achieve this end—especially the recognition of two prices for milk—may be open to criticism, but be that as it may, it has proved successful in practice as, at present, it is almost as remunerative to sell milk for manufacture as for liquid consumption. Up to the present time it has been possible to maintain the liquid price level considerably above that of milk used for manufacture, but it is doubtful if this will always be possible. In the very early days of the Milk Central plan some enthusiasts advocated greater and greater milk production, which step some of the authorities on the subject are inclined to regard as a big mistake, as increased production is likely to lead to a diminution in the difference between the liquid and manufacturing prices.

Milk producers who remain outside the organisation reap some of the benefits without paying so much as the members, but this is a difficulty which cannot easily be overcome in Norway as the Milk Centrals have no power to enforce membership, no matter what proportion of the producers are already enrolled. There is often considerable difficulty in collecting the price-adjusting fees, particularly from producer-retailers who are non-members. In 1933, however, only about one per cent. of the total adjusting fees assessed by the Eastland Milk Central was unpaid. Another difficulty is the question of whether or not small producer-retailers should be included in the price-adjusting scheme, as it has been found that collecting the fees from these costs almost as much as, and in many cases more than, the sum collected. Although there are no definite rules excluding such producers, some of the Centrals ignore all those who have only four cows or less. Such obstacles to the smooth running of the scheme, however, do not appear to be very important. The system as a whole all over the country, and in the Eastland zone in particular, has succeeded in preventing a general decline in milk prices, in keeping the price of milk for liquid consumption above that of milk for manufacture, in levelling out the prices to the individual producers, and in regulating the marketing of dairy products so as to keep the protective duty effective—the main objects for which the marketing scheme was devised.

As is well known, the same method of price levelling as is used in Norway has now been adopted in Britain. The methods of application differ considerably but the principles are exactly the same: producer-controlled organisations, recognition of two distinct prices for the same commodity—milk, pooling the proceeds

of sales for liquid consumption and for manufacture, and returning to the producers a price which makes it almost immaterial to them whether their milk is manufactured or consumed in the liquid form. The Norwegian plan is entirely voluntary, whereas the British, within limits, is compulsory. Norway has her eight Milk Centrals which, though federated into a National Union, operate independently as far as price pooling is concerned; Scotland has her five established or proposed Milk Marketing Schemes, each independent of the other, in a manner very similar to the Norwegian plan; while England goes a step further and has a national organisation split up into eleven regions within which and between which there is a system of price levelling, moving in the direction of a national pool. In all cases it is the same plan applied in ways designed to suit the particular conditions in the different countries, conditions varying from highly industrial in England to almost wholly agrarian in Norway.

CATTLE AND BEEF SURVEY

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A WEALTH of information regarding the production and trade in cattle and beef in the British Empire and foreign countries, collected from many sources and most ably analysed and interpreted, is contained in a recent publication of the Imperial Economic Committee.[1] The trends of production, of demand, of export, and of import are examined first for each country separately and finally for exporting and importing countries in aggregate, and in general the information presented relates to the period commencing before the outbreak of the Great War and extending to the present time.

It is of interest to note the changes which have taken place in the total cattle population of the principal beef-producing countries during the past twenty years. The estimated figures for certain years, distinguishing between the principal exporting countries and the principal importing countries, are as follows :—

	In millions of head			
	1913	1925	1930	1933
Principal exporting countries	163·7	192·5	187·8	172·9
Principal importing countries	110·0	116 0	115·9	124·8
Grand Total	273·7	308·5	303·7	297·7
Of which British Empire countries	37·7	49·6	48·8	48·6

The principal importing countries were largely those engaged in the Great War whose cattle herds had by 1925 little more than

[1] *Cattle and Beef Survey.* Published by the Imperial Economic Committee, June 1934. Price 5s. net.

recovered from the drain of the War years. During this period, however, stocks in the principal exporting countries increased appreciably in response to the increased demand of belligerent countries during and immediately after the War. Taking all countries together, cattle numbers increased by some 9 per cent. between 1913 and 1933, while the estimated increase in population in the same countries between 1913 and 1931 was in the region of 20 per cent.[1]

It would be dangerous to infer from this, however, that the supplies available relative to the population were smaller in recent years than before the War. There is now a more rapid turnover of stock due to younger slaughterings, and improvements in breeds and breeding practices, so that diminished herds do not necessarily mean that potential beef production has been adversely affected. Over the whole of the period under review, however, there has been an appreciable increase in the numbers of cattle devoted to dairying, particularly in the United Kingdom, but in continental countries also, with a consequent deleterious effect on the quality of the beef output. For example, in Scotland in 1929 52 per cent. of the cows in milk and in calf were recorded as being in registered dairy herds, and the percentage in England and Wales must be even greater.[2] Practically one quarter of the beef and veal output of Scotland is derived from the dairy herds, and while some of this meat is from the cross of a beef bull on a dairy cow, almost two-thirds consists of cow beef.[3] This is a point to be borne in mind when considering the quality of the home beef output, and one which is often overlooked. It is possible, too, that increased attention to dairying in the future may result in first-quality beef forming a gradually decreasing proportion of the total output. This would be no new tendency. This increasing output of poor-quality beef, however, may possibly have had some bearing on the decline which has taken place in the volume of frozen beef imports, which the Report shows has been such a marked feature of the post-war years.

A study of the beef market in Great Britain since the War is complicated by the many abnormal conditions of the period, so that it is impossible to study in isolation the effects of all the various factors. The trend of events is largely a matter of historical interest now, and provides little indication of what the beef trade may be like in the future when conditions become more normal, or rather more static.

The estimated production of beef and veal in Great Britain averaged 570,600 tons per annum in the five years 1909-13. From 1923-4, when it amounted to 538,300 tons, it increased until a maximum output of 588,400 tons was recorded in 1929-30. Since

[1] *International Statistical Year Books*, 1928 and 1932-3.

[2] *Report on the Marketing of Live Stock in Scotland.* H.M.S.O., 1933.

[3] *Ibid.*

then, however, the output has fallen rapidly, and in 1932-3 was estimated to amount to only 518,800 tons, or some 9 per cent. less than the pre-war level; included in these figures is the quantity of beef produced from imported cattle which has been estimated to account for 30 per cent. of the home beef production. Imports have been at a substantially higher level in the post-war years. In the years 1909-13 the average annual volume of beef and veal imported into the United Kingdom was 407,800 tons. A maximum import of 723,100 tons was reached in 1927, but between 1927 and 1929 the volume fell appreciably and though it rose again between 1929 and 1931 it has since continued to fall to reach a level of 602,300 tons in 1933. United Kingdom beef imports from British Empire countries accounted on the average for 17·2 per cent. of the annual total of all beef imports in the years 1909-13. Since 1924 this proportion has varied, reaching the low figures of 7·7 per cent. in 1927 and 9·5 per cent. in 1929. An increase to 18·8 per cent. in 1933 brought the proportion above the pre-war level for the first time during the last ten years. While home-produced beef and veal accounted for rather more than half of the total supplies before the War, the position has been reversed since. During the four years ending May 1928 the proportion was only 43 per cent., but in recent years the proportion has risen somewhat.

The net effect of these changes in supplies, together with the changes in population, has been that the estimated annual *per capita* consumption of beef and veal in Great Britain has tended to decline since the War. In the five years, 1923-4 to 1927-8, it amounted to about 71 lb. as against 66 lb. in the years 1909-13. By 1931-2 consumption had fallen below pre-war level, and in 1932-3 it fell still further to some 63 lb. The *per capita* consumption of all meats taken together has, however, tended to increase, averaging 129·6 lb. per annum in the five years preceding the War, and being 144·3 lb. in 1933. This increase is attributable mainly to the increased consumption of pig meat.

One very interesting feature of the post-war period has been the very large increase in the volume of imports of chilled beef, and the gradual decline in the volume of frozen beef imports. These were received in roughly equal volume before the War, the average annual import in the period 1909-13 being 189,100 tons of chilled beef and 186,600 tons of frozen. In 1924 chilled beef imports amounted to 415,100 tons, rising to 520,200 tons in 1927, but since falling to 408,600 tons in 1933. Frozen beef imports in 1924 were 210,600 tons, falling to 118,300 tons in 1929, but since rising somewhat to 145,700 tons in 1933, this recent increase being almost entirely in the supplies from Empire sources. As imports from Empire sources are almost entirely in the frozen state, it is a matter of serious concern to them that the market for this class of beef should be shrinking. As indicative of future possibilities it should be noted that the experience gained with recent experimental shipments of chilled

beef from the Southern Dominions and South Africa has suggested that the difficulties previously associated with the sending of chilled beef over long distances have been largely overcome. At the present time, however, the quality of the cattle stocks is a serious handicap to any great extension of this trade.

Before the War the United Kingdom absorbed 90 per cent. of the world imports of beef and veal. This proportion fell after the War, as a result of the increased demand from continental countries while they were rebuilding their herds after the drain of the War years, and in 1925 the United Kingdom share was only 58·4 per cent. Since then, however, the proportion has steadily risen until in 1933 it was 81·8 per cent. It was not that the United Kingdom was absorbing increasing quantities during these later years—in fact the opposite tendency was apparent—but that the continental countries were increasing their herds and were rapidly reducing their volume of imports by the application of tariffs and quotas. Germany, for example, imported 75,452 tons of chilled and frozen beef and veal in 1924, 123,409 tons in 1927, but since 1931 she has imported none. In 1933, however, most continental countries were still taking a larger share of the world's trade in beef than before the War, while the United Kingdom's share was somewhat below the pre-war level.

Whatever developments may occur in the future, it is apparent that this country will continue to depend upon supplies from other countries for a very large proportion of its beef and veal.

The market for the home beef producer in recent years has not been quite so bad as it has sometimes been made out to be. Beef prices have on the whole offered a strong resistance to the downward pull of the depression. Frozen beef prices fell most severely and fresh beef prices least, indicating some transference of demand to the better qualities of beef. Beef prices have, in fact, fared better than the prices of commodities in general, and beef producers have undoubtedly been favoured as against the majority of primary producers. In 1933 the average price of English beef, first and second quality, in England, was 6⅞d. per lb., a price higher than the average of any of the pre-war years 1905-14. This price maintenance has been due very largely to demand factors. The demand for meat among considerable sections of the population is relatively inelastic, and again the rigidity of wage rates, taken in conjunction with unemployment insurance, has kept the incomes of the meat-consuming classes at a comparatively high level. The decrease in supply during the period under review has, however, also played its part.

With the advent of controlled restriction of imports, and finally the provision of a subsidy to beef producers, it is expected that prices will at least fall no lower and that they may perhaps soon show some improvement. This Report is very careful to point out, however, that as long as there are cheaper varieties of meat

and non-meat substitutes any substantial increase in beef prices will be met by a transference of demand to these alternative foods. Further, it is considered doubtful if a rise in the price of beef can be sustained until a larger amount of purchasing power becomes available for spending on foodstuffs generally—in other words, before there is an improvement in trade and industry generally.

The British beef producer has one distinct advantage, which is not often recognised, over his opposite number in the principal beef exporting countries such as Argentina or Australia. If beef production becomes unprofitable he is usually able to introduce or develop other forms of production and to reduce the emphasis on beef production, or even to cease producing beef altogether according as he sees some economic advantage in so doing. This is not to imply that he can avoid making a loss. For example, the markets for the various agricultural commodities have reacted in very varying degrees to the incidence of the depression since the War, and farmers have reacted to this by changing the emphasis on the various forms of production, and will have been able in many cases to minimise their losses, and in some cases perhaps even to reap profits. The increased attention devoted to dairying since the War is an example of this. Mixed farming may be said to have the virtue of a certain resiliency.

With no immediate alternative to beef production, the position of farmers in large parts of Argentina and Australia must become exceedingly serious when prices fall, and particularly when, as in the case of Argentina, the outlets for their product diminish. They can be excused, therefore, if they do not view with much sympathy the recent developments in the control of imports which are taking place in this country, which is now practically their only market. The total exports of frozen, chilled, and jerked beef from Argentina fell from some 700,000 tons in 1927 to about 375,000 tons in 1933.

The foregoing are some of the points which come to mind in the course of studying this Report, and admittedly have special reference to the United Kingdom or Great Britain. It is not to be thought from this, however, that the Report gives undue prominence to this country's participation in the world trade in beef and veal or that the subject is treated particularly from the British point of view. On the contrary, the situation is examined from the point of view of each country in turn, both as regards internal and external trade, and this provides an admirable background for the final summing up of the world trade as a whole.

The Report is in a form which does not lend itself to compression into a short article. It can only be hoped, therefore, that what has been written here in reference to some of the more important features in the Report may stimulate a desire for a much closer study of what is in reality an incomparable *vade mecum* of this important trade.

THE INCREASE IN THE PROTEIN CONTENT OF OATS OBTAINED BY DELAYING THE APPLICATION OF NITROGEN

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Effects of Fertilisers.—It is now well-established that the judicious use of fertilisers can effect an increase in crop yield which more than balances the cost of treatment, and the serious position of the farming industry is sometimes regarded as a result of over-production due, at least in part, to the increased use of fertilisers. Whether that is the case or not, there is every reason to believe, from a consideration of the figures on the world consumption of fertilisers, that crop production still falls far short of the possible maximum in many countries. It is natural, therefore, that an increasing amount of attention should have been directed in the last few years to the question of the quality of the food produced rather than to its quantity. The effects of different kinds of potash fertilisers, for example, on the cooking and keeping quality of potatoes have been examined, the importance of adequate supplies of certain plant nutrients on the edible and storage characteristics of fruits has received careful study and, in the case of the cereal crops, the composition of both wheat and barley has been the subject of many investigations in different parts of the world.

Wheat and Barley.—In the United States, experiments were commenced more than twenty years ago on the variations in the chemical composition of wheat. They ultimately led to the very important conclusions that the protein content of wheat could be increased by delaying the application of nitrogenous fertilisers until heading time, that this high protein wheat produced as much flour as the same wheat grown under normal conditions and that the high protein flour was definitely superior in baking qualities. The economic aspects of these results are thoroughly appreciated in North America, although it is also generally accepted that the application of nitrogen to the crop is only one of many factors involved in determining the final composition of the grain. In this country, the results of an intensive study, extending over ten years, of the relationship between the chemical composition of barley and its quality for malting purposes, have recently been published. The chief aim in the growing of barley is, unlike wheat, to prevent the protein content of the grain from rising. Consequently, the application of nitrogenous fertilisers for the sake of producing a satisfactory yield must be kept under careful control.

The effects of the numerous factors involved, such as seed and time of sowing, composition and time of application of fertilisers, temperature and rainfall distribution, on the composition and quality of the grain, have all been carefully examined and the conclusions may confidently be described as of the greatest value in the production of barley.

Oats.—In contrast to wheat and barley, oats has not received the attention which it merits. It is a foodstuff of considerable value in the country and its home consumption seems to have been increasing as a result of the unsatisfactory state of the markets. Generally speaking, the home-produced foodstuffs are rich in carbohydrates and relatively poor in protein and, in winter feeding, must be supplemented by imported protein-rich products. It is obvious, therefore, that any convenient method of increasing the protein content of oats would represent a distinct financial gain to the farmer who grew the crop mainly for feeding his own stock.

Various investigations on the metabolism and composition of the oat plant have shown that its chemical and physical characteristics depend upon a great many factors and that, as a result of the wide range of climate in which it can be grown, it shows probably the greatest variability of all the cereals in composition. Even one variety in one season may exhibit extraordinary variation in such properties as protein content and bushel weight on account of the influence of locality; and, of course, season, soil and agricultural practice all play important parts in determining the quality of the product. Although it seems that the American results on the effect of a late dressing of nitrogen on the protein content and baking quality of wheat are not obtained in this country, it was decided to examine the possibilities of the method with the oat crop. The only published paper which could be found dealing with this question (2) showed that very definite positive results could be obtained under the ideal controlled conditions of a greenhouse. The quantities of nitrogen employed were, however, much greater than could safely be used in the field, and it was felt that any method would be of little practical importance unless it could be brought into normal farming practice without prejudice to harvest operations. In view also of the tendency for oats to vary so much in composition, it was quite evident that all that could be studied in a reasonable time was the general response of certain varieties to late dressings of nitrogen over a number of seasons.

Experimental.—To secure some degree of precision in the discussion of small differences in crop composition, it was necessary to conduct the experiments in such a way as to obtain reliable estimates of the normal variations due to soil and seed and in 1929, 1930 and 1931 the Latin Square arrangement was adopted, while in 1933 the method of Randomised Blocks was used. In

1932 and 1934, the primary object of the work was rather to examine, on larger areas, the more obvious effects of treatment on the crop, for there is undoubtedly a general feeling among farmers that a delayed dressing of nitrogen will retard ripening and make the crop more liable to lodge. Every trial or experiment was carried out under normal farm conditions. That is to say, for the more complex experiments a small area, away from headland influences, was selected in a field which was being sown ; and for the larger scale trials ¼ or ½ acre strips, running through the field, were marked off for observation. In the first three years the nitrogen was applied in solution in order to ensure a uniform distribution over the small plots, whilst in the last three years it was carefully broadcast. The small plots were cut, by scythe, at the same time as the remainder of the crop ; on the larger trial strips the grain was usually sampled just before cutting. The grain was allowed to reach an air-dry condition in the field or laboratory and was then threshed by hand. Every sample was submitted to seedsmen for the purpose of valuation. There were rather disconcerting differences of opinion on the relative values of the grain samples from one experiment ; in all the other cases the different samples from any experiment were invariably valued at the same figure. The appearance of the grain, therefore, had apparently not been affected by treatment. Fortunately, for the investigation, the general distribution of rainfall and temperature during the past five or six years has been abnormal so that the experiments have been carried out annually under quite different sets of climatic conditions. Consequently, any general conclusions which may be reached from the results as a whole could almost be said to be independent of climatic influences.

Results.—Samples of the grain were weighed and counted to obtain the grain weight and the bulk of the material was then ground to a powder for determinations of moisture and nitrogen content. The figures for grain weight and moisture content were very irregular and, except in 1930, showed no definite response to treatment with nitrogen. It was fairly evident therefore, that, whatever the effect of delaying the application of nitrogen might be, it did not influence the bushel weight or the amount of dry matter in the grain. This showed that any significant differences in the protein content of the grain could be assessed only by chemical analysis.

A summary of the average figures for the percentage of nitrogen in the oven-dried material and the differences obtained by simply delaying the application of fertilisers are given in the accompanying table.

The Effect of Nitrogenous Fertiliser upon the Nitrogen Content of the Grain

Year	Variety	Application Fertiliser [1]	N. in lb./A	1 None	2 Early [2]	3 Second	4 Late	Per cent. difference between 2 (or 3) and 4
1929	Castleton .	N/S	64	..	1·62	1·67	1·67	+ 2·6
1930	Sandy .	N/S	60	1·79	1·87	1·99	2·00	+ 6·7
1931	Abundance	N/S	30	2·28	..	2·28	2·31	+ 1·5
,,	,,	N/S	60	2·28	..	..	2·52	..
,,	,,	S/A	30	2·28	..	2·27	2·33	+ 2·6
1932	Yielder .	S/A	23	1·67	1·63	..	1·89	+15·2
1933	Victory .	S/A	40	1·89	1·99	..	2·05	+ 3·0
,,	,,	S/A	40	1·86	1·85	..	1·97	+ 6·4
1934	Yielder .	S/A	23	..	1·80	..	1·85	+ 2·8
,,	Victory .	S/A	17	..	1·66	..	1·93	+16·2
,,	Yielder .	S/A	23	1·73	1·66	..	1·75	+ 5·3
,,	,, .	S/A	23	1·86	1·88	..	1·95	+ 3·8

The estimates of the standard error obtained in 1930, 1931, and 1933 were 1·5, 1·8, and 1·0 per cent. respectively. In other words, it may be taken that the probability of the differences found in 1930 and 1933 being exceeded by chance is remote. In 1931, the percentage increases in the nitrogen content are barely significant and in the other cases the significance of the results is not known. It will be observed, however, that the nitrogen content of the grain was invariably increased by delaying the application of fertiliser, and that provides strong reason for the belief that the effect is real and not accidental. The evidence, in fact, is fairly conclusive that the late application of nitrogen does, in general, produce a significant response in the percentage of nitrogen in the grain, and there now remains to be examined the practical and economic aspects of the question.

Discussion of Results.—(a) *The Effect upon the other Constituents of the Grain.* The chief constituent of the grain of oats consists of carbohydrate material, and a small increase in the crude protein at the expense of carbohydrate is of little or no account. A sensible reduction in the amount of oil, which is of considerable importance in the feeding value, would, on the other hand, offset to some extent any advantage of an increase in protein. It has been shown by Mix (3), however, that there is no relationship between the oil and nitrogen in oats. The lack of any correlation between kernel weight and per cent. nitrogen has also been observed by Berry (1); and Gericke (2) found that grain size was not markedly affected by the time at which nitrogen was applied to the crop.

[1] N/S denotes sodium nitrate and S/A ammonium suphate.

[2] The words "early," "second," and "late" are intended to convey respectively that the dressings were applied at or about time of sowing, about the middle of May, at the end of the first week of June or later.

Bushel weight is probably of secondary importance in determining market value when the grain is to be used for feeding purposes, but, in any case, there seems to be no reason to believe that it would be influenced by the treatment required to increase the protein of the grain. There is, therefore, no reason to suppose that any of the other characteristics of the grain would be seriously affected by modifying the protein content.

(b) *The Type and Amount of Nitrogenous Fertiliser.*—In the early stages of the investigation, fairly large dressings of sodium nitrate were given in order to obtain definite responses to nitrogen applied at a particular date. As the results became more definite, the dressings were decreased to normal level and ammonium sulphate was substituted. Various data from other investigations on the metabolism of the oat plant and also the 1931 figures given above indicate that there is no material difference in the effects of the two forms of nitrogen. The ammonium salt is rapidly converted into nitrate under warm moist conditions, but a spell of dry weather might delay its effect and sodium nitrate is commonly employed as a top dressing where the chief object is a quick response. Ammonium sulphate is the cheaper form of nitrogen, however, and its delayed action, where the aim is to postpone the effect, may be regarded as an additional advantage.

In the later experiments, the necessity of applying dressings, which might reasonably be recommended in practice to give the desired result without interfering with the maturition of the crop, was kept in mind. The effects of different dressings are bound to depend upon seasonal and soil factors, for the absorption of nitrogen is closely related to moisture conditions. The results certainly show that, in the wet summer of 1931, a late double dressing of nitrogen exerted a definite influence, but then a normal early dressing had no effect in that experiment, so that either weather or soil or both exerted a predominant influence. In 1932, 1933, and 1934, on the other hand, the harvests were early and dressings of from 17 to 40 lb. N/A were sufficient to produce striking effects. In many cases a dressing of that order is commonly given at the time of sowing and could easily be postponed for 8 or 10 weeks without incurring additional expense in fertiliser or labour.

(c) *The Effect upon Ripening and Lodging.*—In the earlier plot experiments, no definite conclusions could be formed on the influence of the large dressings of nitrogen on the ripening of the grain and any lodging that occurred did not seem to be related to treatment. In the last three years, ripening did seem to be delayed somewhat by the late dressing, but the harvests were early and the farmers concerned did not regard it as of any consequence. In 1932, the straw was short and there was no lodging, while in 1933 the straw was fairly long and a certain amount of lodging took place but on quite unrelated areas. In 1934, the trials were designed principally to examine this question more thoroughly, and the places were

purposely selected in "late" districts in order to make the test as severe as possible. The elevations ranged from about 350 to 780 feet, three of them being over 600. The weather was rather unsettled after the beginning of August, so that the harvest was not so early as in 1933. The straw was quite normal in length where the trials were conducted, so that the heavy rains in August provided a good test of the liability of the crops to lodge as a result of the late dressing of nitrogen. It can confidently be stated that where lodging took place it was either quite independent of the time of applying the nitrogen or was confined to the areas which received the early dressing and which usually carried a longer straw.

(*d*) *The Effect on Yield.*—Although there are many records of the effect of nitrogen on the crop yield, there are very few figures dealing with the relative effects of early and late dressings. The experimental error in measuring the produce from small plots is very large, but the following results were obtained from the randomised block experiments in 1933.

Average Yields of Straw and Grain in lb. per Plot

Set	Dressing of Nitrogen: None	Early	Late	Mean Yield	Standard Error
A . .	12·4	13·9	14·6	13·63	0·72
B . .	9·4	10·7	12·2	10·73	0·45

In set B, the effect of treatment is quite significant and the late dressing has produced a larger yield than the early dressing. A statistical analysis of the results from set A, however, shows that the observed differences are barely significant. Separate figures for grain and straw are not available and, of course, reliable conclusions could not be based on the results for one year. Findlay has reported results (this *Journal* 1932, vol. xv., p. 210) which show that little difference in the yield of grain was occasioned by applying ammonium sulphate at seeding, brairding, or three weeks later, but that the yield of straw was decreased by the late application. Field observations in the 1934 trials seemed to confirm these results, but the actual figures are not yet available. Assuming, meantime, that the yield of grain is not seriously affected by the time of dressing, the value of delaying the application for the sake of increasing the nitrogen content of the grain would seem to be established. Furthermore, the delay would give the grower an opportunity of deciding from the appearance of the crop in May whether an application of nitrogen was necessary or desirable to improve the tillering.

Conclusion.—On the basis of the above observations, it seems that the only disadvantage of bringing about an increase in the nitrogen content of the grain is a possible decrease in the amount of straw. In order to obtain an estimate of the monetary value of the response in the grain, the two high values for the percentage increase in the nitrogen of the grain may be neglected and a figure of 4·2 taken as representing an average increase over six years. The

average percentage of nitrogen in the grain is approximately 1·90, so that the average increase in percentage of protein may be taken as 0·5 (assuming that the crude protein contains 16 per cent. of nitrogen). That gain of protein may be expressed in terms of shillings per ton of foodstuff on the basis of the farm value of oats as given monthly in the *Journal of the Ministry of Agriculture*. In August of this year the cost per unit equivalent is given as 0·87 shillings. An increase of 0·5 per cent. protein is, therefore, equivalent to 0·43 shillings per 100 lb. oats or about 9s. 6d. per ton, a figure which must be regarded as of considerable economic importance. This figure is really a conservative estimate, for the present price of protein equivalent is the lowest for the last eighteen months and is less than half of what it was a year ago. An estimate of the monetary value of any foodstuff is, however, determined by current market prices, so that it is difficult to express the above figures otherwise. Even at the present low value of plant protein, they seem to merit the attention of the farmer who grows an oat crop for home consumption.

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THE FIELD EXAMINATION AND SAMPLING OF SOILS

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Soil problems may be studied (*a*) under natural conditions where the soil occurs, (*b*) in pots or other containers, and (*c*) in the laboratory. Each method is useful in its own way, but it is obvious that the starting-point is in the field, and in the past there has been a tendency to neglect this and to overlook the many valuable indications given by studying soils in their natural environment.

The field study of soils is, of course, particularly useful, and is in fact essential in soil survey work and in problems of soil classification. It is also useful in dealing with soil fertility and with problems of draining, liming and manuring. It is this latter aspect with which we shall deal here.

I. **The Soil Section or Profile.**—Since plant roots usually penetrate below the surface soil or plough layer, it is necessary

to take the lower layers into account in studying a soil. The whole section (usually termed the profile) should be examined from the surface layer down to the underlying parent material from which the soil has been formed.

There are many different kinds of soil profiles found in this country, depending, for example, on the climate of the district, the parent rock, the drainage conditions, etc. Two typical illustrations are given, one of a soil under its natural conditions and the other after cultivation. The uncultivated soils are important in Scotland since four-fifths of the country has never been cultivated :

PROFILE I (Uncultivated Soil)

A_0	Litter of plant remains.
A_1	Blackish or dark grey or dark brown peaty layer.
A_2	Greyish layer, often ashy grey.
B	Rusty brown layer, often very compact and sometimes including a layer of hard pan. Yellow, grey and green spots or streaks sometimes occur.
C_1	Slightly altered parent material.
C_2	Rock or other parent material.

PROFILE II (Cultivated Soil)

Dark grey or brownish plough layer.
Lighter coloured subsoil layer ; may include pan, and grey, yellow, or greenish spots and streaks.
Slightly altered parent material ; may have spots and streaks.
Rock or other parent material.

In examining a soil, a pit should be dug deep enough to show the unaltered parent material, and the various layers should be carefully described. Soils which have never been cultivated or have been uncultivated for a very long time often show the layers indicated in Profile I, especially under a pine wood or heath vegetation, but under natural grass the profile may be quite similar to the profile of a cultivated soil.

The following points should be observed in studying the various layers of a profile :—

1. *Texture and Structure.*—The texture depends partly on the size of the particles which constitute the soil, and partly on the amount of organic matter present. Some idea of the texture may be obtained by rubbing the soil between the fingers and it is possible in this way to classify soils into various textural groups, such as sands, loams and clays.

The structure of a soil depends on the grouping together of particles to form crumbs or other aggregates. The property of forming crumbs is not by any means general, and soils which have this property usually contain more lime and other bases than soils in which the particles do not readily form aggregates. Heavy soils without structure are plastic and sticky when wet, whilst soils of the same texture which show crumb or other structure are friable and give a good tilth.

2. *Colour.*—From the soil colour indications may be obtained on points such as the following :—

The kind of rock from which the soil has been derived.—For example, the soils found on Old Red Sandstone material are usually brownish or reddish, those from granitic material greyish brown, and those from silurian rocks yellowish brown.

Amount of organic matter present.—A dark colour often indicates a high content of humus, and in examining a soil section it will be observed that the surface layers which contain most of the humus are darker than the underlying layers.

Drainage conditions and aeration of the soil.—Bad drainage and consequent lack of aeration of the soil is a very frequent cause of unsatisfactory plant growth. Actual wetness is, of course, the most obvious indication of this condition, but the water-logging may be seasonal and therefore absent at certain times of the year. Other indications from the soil itself are, for instance, grey colouration in the surface layer, grey and yellow mottling, or greenish blue spots and streaks in the subsoil layers.

Leaching of Lime and other Nutrients.—Grey colour is sometimes an indication, not of bad drainage, but of the washing out of nutrients from the soil. In Profile I the third layer consists largely of quartz, and the surface layers of such a soil tend to be very acid and low in plant foods.

3. *Pan and other cemented or compacted layers.*—In an uncultivated soil the layer marked B (Profile I) is more compact than the others. It is sometimes cemented throughout, and in it there is often a definite layer of iron or humus hard pan. This layer is often destroyed, at least partially, by drainage, cultivation, liming and manuring. It is not unusual, however, to find a hard cemented layer (due to iron or humus compounds or both) in soils which have long been under cultivation. A pan at the bottom of the cultivated layer (a plough pan) is also quite common. The latter may be got rid of by deep ploughing or subsoiling, and the same remedy is sometimes possible in other cases of hard pan.

4. *Root Development.*—The depth to which roots penetrate affords valuable indications of soil conditions. Deep rooting indicates that the subsoil conditions are satisfactory, but deep rooting may also be an indication of lack of moisture or shortage of nutrients in the surface layer. Shallow root penetration may indicate bad drainage, or the occurrence of a hard or toxic layer in the soil. It is therefore important in describing a soil to note the root development in the various layers and the greatest depth to which roots penetrate.

5. *Animals.*—Of the forms of animal life which can be recognised in the field, earthworms are probably the most important from a soil-forming and fertility point of view. They aerate the soil, mix its constituents, facilitate drainage and help to incorporate the organic with the mineral matter. Earthworms are said to be very sensitive to soil acidity, or at any rate to lack of calcium. According to Russell[1] " the acid grass plots at Rothamsted contain only few earthworms although the adjoining nearly neutral plots contain many ; Hanley records that the presence or absence of worm casts on pastures is one of the surest ways of showing whether the land is sweet or sour." Moles also appear to avoid sour land, and snails are said to be most abundant where the soil does not show a high degree of acidity.

6. *Parent Material.*—Valuable indications of fertility may sometimes be obtained from the rock or other material from which the soil has been derived. It is obvious that a soil derived from a material which contains little except quartz will have a low natural fertility compared with a soil from a rock rich in lime and other bases. Caution must be observed in the use of geological maps, for most of the agricultural land in Scotland is derived from glacial drift, and it is unsafe to assume, especially where the drift is thick, that it is similar in composition to the underlying rock.

II. Indications of Soil Conditions from Plant Growth. 1. *Natural Vegetation.*—It is impossible in this paper to treat this aspect of the subject in any detail. It may be pointed out, however, that certain plants and types of vegetation are associated with high acidity and low content of plant food, *e.g.* heath vegetation, whilst

[1] E. J. Russell. *Soil Conditions and Plant Growth*, 6th Ed. (1932), p. 416.

others are associated with less acidity and more plant food, *e.g.* clovers and broad-leaved grasses, and others again with impeded drainage conditions, *e.g.* rushes and certain sedges. The varieties and vigour of growth of trees also afford indications of the quality and depth of the soil. In any soil investigation full notes should be made of the existing natural vegetation.

2. *Crops and Weeds.*—The indications of soil conditions obtainable from a study of crops and weeds may be summarised under the following heads. (It must be emphasised that these are merely indications and in most cases do not afford conclusive evidence.)

(a) *Unsatisfactory drainage.*—Lateness of ripening; poor root development; increased susceptibility to certain diseases; occurrence of weeds, such as rushes, certain sedges and mosses, horse-tails, cotton grasses, silver weed, coltsfoot, tussock grass, etc.

(b) *Lime deficiency.*—i. The failure or unsatisfactory growth of certain crops, *e.g.* sugar beet, beans, peas, barley, clover (particularly red clover); patchy appearance in colour of herbage.

ii. The occurrence of certain weeds, *e.g.* sorrel, spurrey and corn marigold.

iii. Incidence of finger-and-toe in turnips; yellow mottling and brown spots on leaves; stunted root development.

(c) *Potash deficiency.*—This is associated with stunted growth, and in cereals with yellow striping of the leaves and with a dying-off of the leaves, first at the tip and then from the edges inwards; there may be failure to reach maturity in cases of extreme deficiency, *e.g.* in certain acid peats; the absence of legumes, especially clover, in grassland is often an indication of potash deficiency.

(d) *Phosphate deficiency.*—The most obvious effects are stunting of the whole plant, especially of the root system, depression of tillering, poor seed production and delayed ripening. In the case of certain plants such as oats and barley, the leaves show a bluish green or purplish colour, and the stems, especially near the base, have a purplish or reddish colour. In grassland there is a tendency for heath types of vegetation to come in.

(e) *Nitrogen deficiency.*—This is associated with stunted growth of the plant, with a yellowish green and occasionally reddish green colour of the leaf, the leaves showing the yellowing all over but beginning at the midrib (*cf.* potash deficiency, where leaves die from the tip and edges inwards). On fruit trees the leaves are yellow, orange or reddish, frequently with reddish spots; they are shed early and the lateral buds die.

(f) *Deficiency in other nutrients.*—Lack of iron is shown by yellowing all over the leaf; lack of magnesium by yellow and brown patches spreading from the midrib.

(g) *Excess of particular nutrients and lack of balance.*—Excessive amounts of nitrogen are associated with dark green leaves and large thick stems. If the nitrogen is excessive in relation to other nutrients there is delayed ripening, and in the case of cereals

probably a tendency to weakness of straw. Insufficient potassium in relation to nitrogen leads to dark-coloured crinkled leaves. Excess of calcium carbonate may lead to yellowing of leaves, and this is also the case with excess of manganese.

III. **Chemical Tests in the Field.**—Various chemical tests are in use, but it must be emphasised that the information obtained from such tests is very approximate, and that in unskilled hands they may be very misleading. Some of the commoner tests are :

1. *The use of acid as an indication of the presence of free lime.*—Usually a weak solution of hydrochloric acid is used, and effervescence is taken as an indication of the occurrence of free calcium carbonate in the soil.

2. *The use of indicators such as brom thymol blue as a measure of degree of acidity.*—A few drops of indicator are added to a small quantity of soil, and the colour developed indicates the degree of acidity. This test, if properly applied, may be quite useful in determining generally whether a soil is extremely acid or whether it has a good supply of lime ; it affords no indication, however, of the amount of lime required by an acid soil. Intermediate conditions are difficult to determine satisfactorily, and in all cases except where the soil is practically neutral or alkaline, more exact laboratory tests should supplement the preliminary field test.

3. *Field tests for potash and phosphate.*—These also depend on indicators, usually after a pre-treatment with a weak acid. Such tests, however, can be carried out in a far more satisfactory manner in the laboratory.

IV. **Sampling of Cultivated Soils.**—From the foregoing it will be seen that a considerable number of valuable indications of the soil conditions may be obtained from a field examination of the soil and of its vegetation. In the majority of cases, however, these are merely pointers and it is not generally possible to determine from field observations alone the extent of a deficiency in any nutrient or other fertility factor. For a more accurate determination of these, further data are required, and may generally be obtained from a study of samples of the soil by means of physical, chemical or biological methods at a station equipped for the purpose. In sampling a soil an endeavour should be made to obtain as representative a sample as possible from the area to be examined. Any abnormal or irregular patches in a field should be sampled separately and not included in the main sample, and definite information should be given as to the nature of the irregularity, *e.g.* " strip on west side of stackyard field, where finger-and-toe occurs in turnips," " wet peaty hollow about ½ acre in extent in centre of stackyard field."

Soil samples intended for laboratory examination should not be taken immediately after the application of lime, dung, or artificial fertilisers, since a sample taken before these have had

time to become incorporated with the soil will almost certainly be contaminated by them.

Samples of soil may be taken conveniently by means of a spade, trowel or auger. The bulk of the sample taken for examination depends on the object in view. For pot experiments, where quantities up to 1 cwt. or more of surface soil may be required, sampling will be done most easily by means of a spade; spadefuls being collected from as many spots as possible in the area under examination.

In soil advisory work at the Macaulay Institute for Soil Research, where laboratory tests are carried out with a view to determining whether the soil is being adequately supplied with plant foods, the procedure is to collect 2 lb. samples of both soil and subsoil by one or other of the following methods :—

1. *Surface Soil Sample.*—(a) *Spade or Trowel Sampling.*—With a clean spade or trowel remove a slice of soil about 1 inch thick to a depth of 9 inches, or alternatively to the normal plough depth. Collect this sample in a clean pail. Further samples should then be taken in the same way from different parts of the field or area under consideration until at least a dozen such samples have been collected in the pail. The greater the number of spots sampled in a given area the greater is the likelihood of the final sample being representative of the area. After the soil has been collected in the pail from as many different parts of the area as possible it is mixed thoroughly and a representative sample of about 2 lb. of soil taken for laboratory examination. This is collected conveniently in a brown paper bag, preferably one with waxed paper lining, and the remainder of the sample in the pail is discarded.

If more than one type of soil occurs in a field (often indicated by differences in surface features), each type should be sampled separately. Even if the soil appears to be uniform it is desirable in large fields to take a separate 2-lb. sample from every 10 acres or so.

(b) *Auger Sampling.*—Augers of 1¼ inch diameter are very suitable. With the auger a boring is made in the soil to a depth of 9 inches. The auger with the soil adhering to it is pulled out, the soil removed and collected in a paper bag. Further samples should be taken in this way from different parts of the area to be examined, the borings being continued until a 2-lb. sample of the soil has been collected. As in the foregoing method of spade sampling, one 2-lb. sample should be taken from every area of 8 to 10 acres, or less.

2. *Subsoil Sample.*—In the sampling of subsoils for normal advisory purposes, it is generally sufficient to regard as subsoil that fraction of the soil lying between the arbitrary depths of 9 inches and 18 inches below the surface. In uncultivated soils and in special investigations it may be necessary to sample individual layers separately.

With a spade remove the surface soil to a depth of 9 inches

from an area of about 1 square foot. Clean the spade and remove a slice of the subsoil about 1 inch thick to a further depth of 9 inches. Collect this sample in a clean pail. Further samples should then be taken in the same way from five or six parts of the area under consideration. (There is less risk of casual contamination of the subsoil by animals, etc., than there is of the surface soil, so that fewer spots will generally be sufficient to give a subsoil sample.) As in the sampling of surface soils, the composite sample in the pail is mixed thoroughly and a representative sample of about 2 lb. taken for examination.

Where the subsoil is not too stony the subsoil sample may also be taken by means of an auger. The surface soil is removed with a spade as indicated above, and auger borings taken to a depth of 9 inches in the exposed subsoil. Three or four borings may be taken from each hole, and sampling continued until 2 lb. of subsoil has been collected.

V. **Field Notes.**—Samples intended for laboratory examination and taken according to either of the methods described above are marked surface soil, or subsoil, dated and labelled with the name and address of the farmer and the name or number of the field. These are forwarded to the laboratory, together with notes on the rotation followed, the yields obtained, the previous manurial treatment and liming, and general field observations. These may be collected conveniently in tabular form, and on page 418 is a specimen of the form for field notes which is used in advisory work at the Macaulay Institute for Soil Research.

Summary.—Since plant roots usually penetrate below the surface soil, the underlying layers as well as the surface soil must be taken into account in studying soil conditions. In such a study attention must be paid to texture and structure, colour, evidences of pan formation, depth to which roots penetrate in the soil, signs of animal life, and the nature of the parent rock.

Many useful indications of soil conditions may be obtained from a study of the natural vegetation of uncultivated areas, and from the crops and weeds on cultivated ground. A brief outline has been given of the indications, by plants, of bad drainage, sourness and deficiency in nutrients.

Although the above indications obtained in the field are useful, it is generally necessary to make a more detailed examination in the laboratory. In order that a sample of soil intended for laboratory examination may be representative of a given area, small samples must be taken from a large number of spots in the area under consideration. In normal advisory work on cultivated soils it is generally sufficient to take a representative sample of surface soil to a depth of 9 inches or alternatively to the normal plough depth, and a representative sample of subsoil from 9 to 18 inches below the surface. Methods have been described for the taking of these samples.

Map No . . . . .

FIELD NOTES

No. of Field Stackyard Field

Name of Farmer

Drainage Conditions. (If known, state type, depth, and distance apart of drains) . Good. 2-ins. tile drains, 2 *feet deep*, 30 *yards* apart.

Name of Farm and Locality

YEAR	ROTATION CROP	YIELD	MANURIAL TREATMENT (Including farmyard manure)	LIMING (Approx. month)	REMARKS
1935	Turnips	..	..	..	..
1934	Oats	Medium 6 qrs.	None	..	Crop standing but too short.
1933	3rd year Grass	Medium	None	..	Yorkshire Fog abundant. Sheep's Sorrel fairly common. Clover medium.
1932	2nd year Grass	Medium	None	..	Clover medium.
1931	Hay	Poor	4 cwt./acre basic slag in November	..	Clover poor.
1930	Oats and Grass and Clover Seeds	Good 8 qrs.	3 cwt./acre grain and clover fertiliser	..	Regular.
1929	Turnips	Medium 18 tons	15 tons dung/acre 5 cwt. turnip fertiliser (2% nitrogen, 14% phosphoric acid, 5% potash)	..	Spurrey abundant Considerable amount of finger-and-toe.

Notes : (*a*) In Column 3 approximate figures should be given if possible, but if these are not available, state whether the crop was "Good," "Medium," or "Poor."

(*b*) In Column 6 (Remarks) state, for example, whether clover in pasture is good or absent; whether grain lodges; whether diseases such as "Finger-and-toe" in turnips, or "Scab" in potatoes have been observed. State, if possible, the common weeds.

(*c*) Any other observations which may be of value, *e.g.* 'General difficulty experienced in getting pasture established in this field; soil very heavy and sticky," etc.

The Milk Act, 1934

THIS Act came into operation on 15th August 1934. It makes provision for—

(1) *Payments from the Exchequer in respect of Milk used for manufacture.*—These payments are to be made during the two years' period as from April 1934, for the purpose of guaranteeing to the Milk Marketing Boards standard prices of 5d. per gallon in summer (April to September) and 6d. per gallon in winter. The rates per gallon of the advances will be determined monthly and will be—

(*a*) in respect of milk sold for manufacture, the difference between the standard price and the cheese-milk price (as certified in terms of the Act [1]) or between the standard price and the net cost per gallon of the milk to the purchaser (whichever difference is the less);

(*b*) in respect of milk used for manufacture of milk products by the Boards, the difference between the standard price and "the appropriate manufacturing milk price" (the market price, as certified under the Act, for the sale of milk for the manufacture of the product); and

(*c*) in respect of milk converted into cheese on farms, the difference between the standard price and the cheese-milk price.

Repayments in respect of these advances are to be made by the Boards during the two years' period beginning April 1936, in any month when the cheese-milk price exceeds the standard price increased by one penny, the rate per gallon of repayment to be equal to the excess.

(2) *Improving the Quality of the Milk Supply.*—Section 9 of the Act authorises an expenditure of sums out of moneys provided by Parliament not exceeding £750,000 during a period of four years, beginning on "an appointed day" with the object of securing, so far as practicable, that milk supplied in Great Britain for human consumption is pure and free from infection of any disease.

(3) *Increasing the Demand for Milk.*—Section 11 authorises an expenditure out of moneys provided by Parliament of not more than £1,000,000 over a period of two years in payment of contributions to Milk Marketing Boards in Great Britain, to the extent

[1] Section 4 of the Act prescribes that the cheese-milk price for any month shall be the excess over 1¾d. of the average prices per lb. at which cheese such as is commonly known as "New Zealand finest white" and "Canadian finest white" was sold wholesale in Great Britain during the immediately preceding month.

of one half of the expenses incurred by them in giving effect to approved arrangements for increasing the demand for milk.

It should, perhaps, be explained that the milk marketing schemes in both England and Scotland started under particularly unfavourable conditions. Mainly as a result of increased importations from overseas, coupled with, in the case of some exporting countries, currency depreciation in relation to sterling, the price of cheese, which largely determined the value of manufacturing milk, had fallen to unprecedented levels, and soon after the introduction of the schemes, milk for butter and cheese manufacture was worth only 3¼d. to 3½d. per gallon. Such low values constituted a threat to the stability of the schemes, and gave rise to a situation—the possibility of which had been foreseen by the Reorganisation Commission for Milk (England and Wales)—which required emergency action by the Government. Accordingly, the Government framed a policy which had for its objects :—

(i) the insurance of organised milk producers to some extent against the effects of the low values for milk products ;

(ii) the easing of the period of transition from individual sales and receipts to schemes on a pooling basis ;

(iii) the cleaning up of dairy herds with a view to the ultimate eradication of bovine tuberculosis ; and

(iv) the increasing of the consumption of liquid milk.

With regard to (iii) and (iv), it is undoubted that if an increase in consumption is to be obtained, it must be based on public confidence as to the purity of the supply, and while realising that the only complete solution of the problem of tuberculous milk, viz., the total eradication of bovine tuberculosis from all herds, cannot be attained without considerable expenditure over a prolonged period, the Government agreed, meantime, to provide the sum of £750,000 in order that a start might be made in solving the problem.

As regards the Exchequer contribution of £1,000,000 on a £ for £ basis for the purpose of increasing the demand for milk, the grant will be available only for the carrying out of arrangements previously submitted by the milk marketing boards and approved by the Minister (*i.e.* as regards Scottish schemes, the Secretary of State for Scotland). The programmes submitted by the boards will not be approved unless they contain provision for the supply of milk to schools at reduced rates.

It will thus be seen that the grants referred to in the two preceding paragraphs are complementary parts of a policy which is designed in the interests of both the urban and the agricultural population.

A Winter Spray for Insect Control

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IN the early years of tar-oil distillate spraying, it was hoped that complete control of insect pests would be obtained by winter spraying alone. The continued use of tar-oil washes, however, has not solved the problem of pest control, but has presented the pests in a different order of importance. Aphis and apple-sucker are controlled by tar-oil distillate, while sawfly and red spider are unaffected. It is now common knowledge that since the advent of the tar-oil distillate sprays, red spider infestation has in many places increased very considerably. This increase is not alone due to the fact that the eggs of the red spider are not killed by the spray, it is also due to the destruction by the spray of certain useful insects which normally prey upon the winter eggs of the spider. The result of this is that a biological check on the normally rapid increase of the red spider is removed.

A great deal of work in America shows that mineral oils are fairly efficient in controlling both the sawfly and the red spider, but they do not kill the eggs of aphis and apple-sucker. Recent work shows that combined sprays of mineral oils and tar-oil distillates for use in the dormant period are more efficient both as aphicides and for killing sawfly and red spider than any of these materials used alone. The greatest degree of control of these pests is obtained by a combined tar-oil distillate-mineral oil spray applied during the winter months.

The tar-oil distillate which is used for a winter wash is that fraction which is obtained from straight-run tar oils boiling between 200° C. and 360° C. The presence of tar acids is regarded as undesirable.

The mineral oil generally used for a winter wash is a half-refined lubricating oil, technically known as a spindle oil.

The great difficulty up to the present time in preparing a combined tar-oil distillate-mineral wash has been in obtaining a satisfactory emulsifying agent.

The requirements of an emulsifying agent are :

(1) To make the wash readily miscible with water.

(2) To form a stable spray when the wash is diluted with water. If any creaming takes place after the emulsion has been allowed to stand for some time, it must be readily converted to its original condition by stirring.

(3) It must give the wash a high wetting power.

(4) If at all possible, to form a one-solution emulsion for convenience and ease of handling.

Of a large number of substances tried at Aberdeen as emulsifying agents, a new sulphonated oil named Whitcol has been found to be

the most satisfactory. When used with a tar-oil distillate-mineral oil mixture it fulfils all the requirements for an emulsifying agent enumerated above.

Preparation of the Winter Wash.—The wash is prepared by mixing together equal parts of tar-oil distillate and mineral oil, and to three parts of this mixture adding one part of the emulsifying agent.

Directions for Use.—The effective concentrations of the winter wash differs with the species of insect and with the particular kind of plant. For spraying apple and pear trees a concentration of one gallon of wash in ten gallons of water is generally effective, except in severe infestations of red spider, when a concentration of one gallon of wash in seven gallons of water is used. For spraying plums, damsons, cherries, and the smaller fruit bushes, a concentration of one gallon of wash in twenty gallons of water is effective. On account of their susceptibility to spray injury, this concentration should never be exceeded in the case of plums and the smaller fruit bushes.

Time of Application.—Winter washes should always be applied while the buds are dormant. As a general rule, in Scotland winter sprays can be applied from the end of November up to the end of January for pears, plums, and the smaller fruit bushes, and to the middle of February for apple trees. The spraying should be done on calm days when the temperature is above 40° F. Spraying should always be avoided if there is any likelihood of frost within nine hours after treatment.

Method of Spraying.—Tar-oil distillate-mineral oil washes are contact insecticides, so that to obtain maximum results all surfaces of the plants, including the larger limbs and trunks, should be completely wetted with the spray. As far as possible, spraying should always be done with the wind. Since tar-oil distillates burn the skin, the eyes, hands, and face of the operator should be protected. For the protection of the eyes goggles should be used, while the hands and face should be covered with grease. In cases where the worker is very susceptible to tar poisoning, the face should be covered with a mask and the hands should be protected with waterproof gloves. Experience has shown that individuals vary greatly in their susceptibility to spray materials. Where burning of the skin has occurred, it may be relieved by first washing the affected area with vinegar diluted at the rate of one part to four parts of water, and then applying lanoline.

Experimental.—This spray was tried last winter on a number of apple and plum trees at the concentrations recommended. In each case, infested twigs which had been sprayed while on the trees, together with untreated twigs, were taken to the laboratory and incubated. In all cases none of the eggs of aphis, apple-sucker or red spider hatched on the treated twigs, while on the untreated twigs a large number hatched out. This shows that

where this spray is properly applied complete control of these pests can be obtained, but if any infested part of the plant is left unsprayed, then the eggs will hatch and reinfest the sprayed portion of the plant in spring.

Poultry Houses.—This spray may also be used for spraying the interior of poultry houses. When used at a concentration of 10 per cent., *i.e.* one gallon of wash to ten gallons of water, it gives effective control of lice and red mite.

This work was carried out under the direction of Professor J. Hendrick, to whom the author is greatly indebted for valuable advice and criticism. He is also indebted to Dr Guy Morison, Advisory Officer in Entomology, for valuable assistance in the investigation of the effect of the spray upon the different pests.

Notes from Agricultural Colleges

Craibstone

Grasses and Clovers, 1934.—One might have expected after the extremely dry season of 1933 that the stand of grasses and clovers would be thinner and less vigorous than usual. This, however, was not the case, as red clovers especially were possibly better in the country generally than they have been for several years. This may be accounted for partly by the fact that the seed of English red clover was plentiful and of exceptionally good quality. so that very little foreign seed was sown, and partly by the early harvest which enabled the "new grass" to have a much longer growing period than usual and to get established before winter.

As the winter was so mild and there was no sustained period of frost—only on a few nights in February and March was there ground frost, while the day temperature was well above freezing point—it was expected that foreign red clovers would be more prominent than they usually are. But, although some of these were better than usual, none was so good as English or New Zealand. As indicating the mildness of the winter an ordinary mixture of grass and clover which was sown with wheat in the middle of September is now as thick and fresh as one could wish.

Altogether, fourteen samples of English Broad-leaved from several counties were sown, and all except one produced good vigorous crops of both hay and aftermath; the seed of the exceptional sample was of low germination and was evidently old.

It is only now and again that seed of New Zealand red clover is obtainable, but when tried previously it did well. In this year's trial five samples, all Broad-leaved, were included. Four of these produced very good crops of hay and aftermath, but the fifth was poorer.

The four samples of Canadian Broad-leaved tried, although not so good as English, were better than Canadian have been in any previous trial at Craibstone, while the aftermath was fairly good.

None of the Chilian (four samples) or French (three samples) were as good for hay as Canadian, but the aftermath was fully better in both cases. Polish, as it always has been, was very poor, both in hay and pasture.

While the hay crop produced from Montgomery Late-flowering was generally good and vigorous, the different samples were more varied in type and time of flowering than they usually are. Of twenty-one samples, seven were very vigorous and late in flowering, five were medium, while three were much poorer and six which were otherwise quite good were mixed with Broad-leaved, which showed very distinctly in the aftermath. The seed of two samples of Montgomery grown in Suffolk, and one in New Zealand, was much better than seed grown in Montgomery, while the hay crop was quite as good.

Two samples of Cornish Marl and one of Norwegian were very late and much less vigorous than they had been when tried previously. The Late-flowering Cornish Marl should not be mistaken for Dorset Marl. The latter is a good vigorous type of Broad-leaved.

Eighteen samples of English Late-flowering were included, but of these one was Broad-leaved. Four of the samples originated in Suffolk, three in Hertford, two from the Cotswolds, and one each from Bedford and Essex, while the remaining six were just English. All these except one of the last were good and vigorous and the aftermath came much quicker than Montgomery.

Of eleven Swedish samples, six were very good, three were somewhat mixed, while the other two were very poor. The aftermath of the good samples was similar to good English, while the others were poorer.

Six samples of American Mammoth were fully better than they have been in previous years, while the aftermath came quicker even than the English Late-flowering, but it was much thinner on the ground.

One sample of Courland was extremely poor both in hay and aftermath.

The following are typical results obtained from several of the plots. The same seed mixture was sown in all cases, 3 lb. of the different samples of red clover being included. Samples of the hay were taken and separated into grass and clover.

	Per acre		
	Red Clover	Grass	Total
Broad-leaved	cwt.	cwt.	cwt.
Canadian	17·6	29·9	47·5
Chilian	13·9	28·4	42·3
Dorset Marl	23·8	26·8	50·6
French	12·7	28·3	41·0
New Zealand	27·1	27·1	54·2
Polish	4·6	25·5	30·1
Suffolk	24·2	28·5	52·7

	Per acre		
	Red Clover	Grass	Total
Late-flowering	cwt.	cwt.	cwt.
American Mammoth . .	15·8	30·8	46·6
Courland	3·2	25·8	29·0
Essex	34·5	20·3	54·8
Hertford	30·0	26·0	56·0
Montgomery . . .	35·0	23·4	58·4
Suffolk	31·8	22·1	53·9
Swedish	30·1	24·7	54·8

It will be noted that there was more red clover in the case of the good Late-flowering, while they had generally a greater adverse effect on the grasses than the Broad-leaved. On the other hand. the scarcity of red clover in the hay in the cases of Polish and Courland also had an adverse effect on the grasses. This, undoubtedly, was due to the smaller amount of nitrogen provided by the red clover. The aftermath of these was equally poor.

Several complaints have been made recently regarding the difficulty of getting red clover to grow, even although 6 or 7 lb. of seed were sown. While in some cases the cause was found to be the use of unsuitable seed, the most frequent cause was the inclusion in the seed mixtures of large quantities—15 to 30 lb.—of Italian ryegrass. While this grass is undoubtedly extremely useful for grazing in early spring, in all trials that have been carried out during many years its inclusion in the mixture for hay has reduced the crop, mainly through the small amount of red clover present. Italian ryegrass is much more useful for early grazing or cutting than for hay. In a trial this year the following result was obtained :

	Per acre			
Mixture sown	1	2	3	4
	lb.	lb.	lb.	lb.
Perenniel Ryegrass .	20	10	—	15
Italian Ryegrass .	—	10	20	—
Timothy (Scots) .	—	—	—	5
Red Clovers . .	4	4	4	4
Alsike Clover . .	1	1	1	1
Weight of Hay produced per acre (cwt.)	58	52	51	61
Of which Clovers (cwt.)	39·3	26·6	18·1	34·2

The inclusion of timothy for one year's hay has always increased the yield.

The comparative value of timothy for grazing was tested several years ago, when plots of one acre each were sown with (*a*) cocksfoot, (*b*) perennial ryegrass, and (*c*) timothy, along with clovers. Each was fenced off and grazed separately with sheep. The live-weight increases obtained were—cocksfoot 168 lb., perennial ryegrass 126 lb., timothy 255 lb.

Timothy is a very sensitive grass and the amount present in hay or pasture may be greatly reduced by three different circumstances, (1) sowing along with too large a proportion of quick-growing grasses, especially perennial ryegrass, which acts adversely on it; (2) sowing seed from an unsuitable source, especially American (both the United States and Canada) which has been found to be much less lasting than seed grown in Scotland (mainly in Stirlingshire) and in several European countries. Unfortunately, much of the seed of timothy sown in the North of Scotland is of American origin; (3) grazing too severely by stock, especially sheep.

Among samples obtained two or three years ago was one from Poland. Instead of the plants being of the usual upright habit of growth they were all dwarf and spreading. Since that time some samples from Latvia and Lithuania have also been of the dwarf-spreading type, although other samples from Poland and these countries have been of the upright type.

The Plant-breeding Stations in Wales and Scotland have also dwarf selections. Of all these dwarf types the Welsh appears to be the most vigorous, but none of them has been tested sufficiently long in the field to form an opinion as to its value in mixtures. A disadvantage of the Central Europe samples of timothy is that most of them contain a considerable amount of weed seeds.

This spring several samples of Finland timothy were obtained. All these appear to be of an entirely different type from both the ordinary upright and the dwarf, being later in flowering and broader and softer in the leaves. They are being tried in mixtures.

The following weights, which were obtained from the plants of several samples which were sown in 1932 and transplanted in the spring of 1933, will give an indication of the relative value.

	lb.
American (Canada)	$3\frac{3}{4}$
,, (U.S.A.)	$3\frac{1}{4}$
Danish	$8\frac{1}{4}$
Norfolk	$3\frac{1}{2}$
Saxony	$7\frac{1}{4}$
Scots 1	$6\frac{3}{4}$
,, 2	$4\frac{3}{4}$
,, 3	$7\frac{1}{2}$

Swedish samples have also been very good. During last winter the plants of the American, Norfolk and some plants of Scots No. 2 were very poor, and they were very slow in starting growth in spring, and altogether they were very unsatisfactory. The poor plants of Norfolk and Scots No. 2 were very similar to the American, and it would appear as if the Norfolk farmer had sown American seed and seeded it, while the Scots farmer had evidently sown a mixture of his own home seed and American. Scottish farmers,

who save timothy seed, must sow true acclimatised seed and not American if they wish to supply a first-class article.

Of a number of samples of cocksfoot included in the same seed mixture sown in the field, and now in its third year, one from the Welsh Plant-breeding Station at Aberystwyth was thicker on the ground than any of the others. The leaves were comparatively narrow. Like New Zealand cocksfoots, it was rather late, however, in starting growth in spring and was not so well eaten as Danish had been.

Of three samples of Swedish cocksfoot, Hammenhöeg was the leafiest and latest in flowering. Tardus was similar to Danish, being early in flowering and later tending to produce a large proportion of stalks, while Scandia was intermediate.

Several new types of perennial ryegrass were tried. These included (1) several samples from New Zealand said to be of the leafy permanent type and saved from old pastures in the Hawkes Bay district and termed " mother seed." There were also samples of once-grown from this. (2) Two samples named Downland from Hampshire, presumably from old pastures there. (3) One from the Welsh Plant-breeding Station at Aberystwyth and (4) Swedish Victoria.

A preliminary trial of individual plants of these was made alongside ordinary commercial perennial ryegrass (home-grown, Ayrshire and Irish) and Kent Evergreen. The following weights were obtained from ten plants of each.

	oz.		oz.
Aberdeenshire	16	Irish	16
Ayrshire	16	New Zealand mother seed	28
Downland	14	New Zealand, once grown from mother seed . .	12
Kent Evergreen . .	39	Victoria	20
Kent Evergreen, once grown	20	Welsh	50

The plants of the Kent Evergreen were, as usual, very leafy and vigorous and spread out well, but the Welsh sample was distinctly superior. While the New Zealand mother seed was quite good and better than ordinary commercial perennial ryegrass, it was not nearly so vigorous as the Welsh or Kent.

The once-grown samples of both the Kent Evergreen and New Zealand were not nearly so good as the originals, although the former was fully better than ordinary commercial seed. Victoria was similar to the once-grown Kent Evergreen.

There was practically no difference between ordinary commercial from the different sources, and each contained a small proportion of plants much leafier than the majority and, no doubt, these are the plants that persist in pastures and with the assistance of the nitrogen provided by wild white clover spread out and help to form a good sole.

Ten individual plants from samples of Italian ryegrass were also weighed and the following weights were obtained.

Danish	$3\frac{1}{2}$ lb.
French	$1\frac{3}{4}$,,
Irish	3 ,,

The French was distinctly less vigorous than either the Danish or Irish.

An application of nitrogen to a new grass crop which originally contains a large proportion of red clover may have a different effect on the amount of red clover harvested, depending on the time it is cut. When cut frequently, the amount of red clover present may decrease more quickly than when the crop is made into hay, as in the following case where different quantities ($\frac{1}{2}$ cwt. and 1 cwt. after each cut) of sulphate of ammonia were used.

	Per acre (green weight)		
	Grass cwt.	Clover cwt.	Total cwt.
No Nitrogen			
1st cut . . .	33·9	96·6	130·5
2nd ,, . . .	29·7	57·1	86·8
3rd ,, . . .	8·6	14·7	23·3
4th ,, . . .	14·6	15·3	29·9
5th ,, . . .	17·9	11·9	29·8
	104·7	195·6	300·3
$\frac{1}{2}$ cwt. Sulphate of Ammonia			
1st cut . . .	60·0	83·0	143·0
2nd ,, . . .	48·6	50·6	99·2
3rd ,, . . .	15·4	13·6	29·0
4th ,, . . .	30·0	8·0	38·0
5th ,, . . .	31·2	5·2	36·4
	185·2	160·4	345·6
1 cwt. Sulphate of Ammonia			
1st cut . . .	81·1	84·4	165·5
2nd ,, . . .	71·4	38·1	109·5
3rd ,, . . .	24·2	13·0	37·2
4th ,, . . .	48·8	5·4	54·2
5th ,, . . .	40·7	2·4	43·1
	266·2	143·3	409·5

It will be seen that, although there is a reduction of red clover, the sulphate of ammonia increased the total crop. Where, however, sulphate of ammonia was applied to the hay crop alongside, it had no effect on the yield, although a week or two after it was applied it showed quite an apparent beneficial effect, but the red

clover got the upper hand again and the final result was that there was no difference in the weight obtained. Both the No Nitrogen plots and the plots that got 1 cwt. sulphate of ammonia produced 59 cwt. of hay per acre, of which fully half was clover. The aftermath cut at the same time as the 5th cut above weighed 165 cwt. (green) per acre, and of this 94 cwt. were clovers. On the other hand, where the seed mixture contained Italian ryegrass instead of perennial ryegrass, and where there was consequently much less red clover present, the sulphate of ammonia increased the hay crop, the weights being—

No Nitrogen	39·1 cwt.
1 cwt. Sulphate of Ammonia .	46·9 ,,

Review

Practical Bacteriology: An Introductory Course for Students of Agriculture. Andrew Cunningham, D.Sc., Advisory Bacteriologist, Edinburgh and East of Scotland College of Agriculture. Second Edition (revised and enlarged). Oliver & Boyd, 1934, 7s. 6d. net.

THE publication of a new edition of Dr Cunningham's book on *Practical Bacteriology* will be welcomed by all who have used the first edition. The text of the new edition has been almost entirely rewritten and brought up to date. By the judicious use of smaller type for certain of the practical details, the contents of the book have been almost doubled without any appreciable increase in size or any increase in price.

The first three chapters deal with general bacteriological technique. The section on the preparation of media has been largely increased, while in Chapter III a new division dealing with the cultivation and characterisation of the moulds, yeasts and actinomycetes has been added. Chapter IV treats of the bacteriology of milk and dairy products, while a new section has been added on the examination of water. Succeeding chapters deal with the bacteriology of soil and farmyard manure and with plant and animal diseases, the latter two sections having been considerably extended. The appendix contains an account of the bacterial tests for graded milk.

Dr Cunningham's style is clear and concise; all the tests are fully described; the descriptions are terse and to the point, and there is a gratifying absence of all vagueness and looseness of expression.

The book will be a valuable help to all teachers of bacteriology and can be recommended without any reserve.

Agricultural Returns for Scotland, 1934

THE Preliminary Statement of the Agricultural Returns taken in Scotland as at 4th June 1934 shows that the total area under crops and grass amounts to 4,599,700 acres, comprising 2,995,600 acres of arable land and 1,604,100 acres under permanent grass. The total acreage is the smallest recorded since 1874, while the area of arable land, which has now fallen below the 3,000,000 mark, is the smallest recorded since the Returns were first taken in 1866, being less than in 1933 by 34,500 acres. The area under permanent grass has increased this year by 20,500 acres, making the actual diminution in the area under crops and grass 14,000 acres.

The area under rotation grasses and clover, 1,425,500 acres, has decreased by 52,000 acres, while the "tillage" area, *i.e.* that under grain, green crops, etc., is 17,500 acres larger than in 1933.

There have been reductions in the areas of oats, mixed grain, beans, potatoes, and vetches, tares, etc., for fodder amounting to 46,000 acres. Increases in the areas of wheat and barley amount to 49.800 acres, and of rye, peas, turnips and swedes, mangolds, sugar beet, cabbage, rape, small fruit, other crops and bare fallow to 13,700 acres.

The outstanding features of the crop returns are the increases in the areas under wheat, barley and sugar beet, and the decreases in oats and potatoes. Wheat, with an increase of 14,600 acres, or 18·6 per cent. over 1933, reaches an area of 93,000 acres, which is the highest recorded since 1875. The highest war year acreage, that of 1919, was 79,500 acres. Barley has increased by 35,200 acres, an increase of 58·9 per cent. over 1933 to 95,000 acres. This acreage is 11,600 below the 1930 acreage. Oats have decreased by 35,900 acres to 820,000 acres. The area under potatoes has decreased by 9500 acres to 143,000 acres. Sugar beet has increased from 1700 acres last year to 7500 acres this year, while the acreage under small fruit shows an increase of 600 acres, accounted for by raspberries and strawberries. There are increases in the acreage under carrots of 287 acres and increases in other crops not separately mentioned in the table amounting to 1100 acres, while onions show a decrease of 26 acres.

Of the area under permanent grass, 179,100 acres were cut for hay and 1,425,000 acres were grazed, while of the area under rotation grasses and clover, 390,500 acres were cut for hay and 1,035,000 acres were grazed. The area under permanent grass for mowing was greater than in 1933 by 200 acres, and under rotation grass for mowing was less than in 1933 by 1000 acres ; the total area cut for hay is thus decreased by 800 acres.

The live-stock returns show that horses, sheep and poultry have decreased in numbers, while cattle and pigs have increased.

Horses used for agricultural purposes are fewer than in 1933 by 1500, the total, 112,400, being the smallest on record. Unbroken

horses of one year and above show an increase of 600, or 4·2 per cent., while foals show an increase of 600, or 11·1 per cent., on last year's figures. The decrease in horses of all kinds is 1100, or 0·7 per cent.

The total number of cattle, 1,305,700, is greater than last year's figure by 12,100, or 0·9 per cent. With the exception of other cattle two years old and above, which are down by 8400, or 4·2 per cent., all classes of cattle show increases.

The total number of sheep, 7,673,000, shows a decrease of 138,100, or 1·8 per cent., as compared with 1933. Ewes, which number 3,350,000, are 35,700 less than in 1933, a decrease of 1·1 per cent., while lambs have decreased by 90,900 or 2·7 per cent. Rams show an increase of 900, while other sheep, one year old and above, show a decrease of 12,400, or 1·3 per cent.

Pigs, which total 199,700, show an increase of 32,700, or 19·6 per cent. on last year's figures. Sows have increased by 5100, or 23·3 per cent., boars by 200, or 8 per cent., and other pigs by 27,400, or 19·2 per cent.

The returns of labour employed (excluding occupiers of holdings, their wives and domestic servants) at 4th June 1934 are given below, together with the figures for 1933. Regular workers are fewer by 200, while casual workers are also fewer by 200.

The returns of poultry at 4th June 1934 are also given below, together with the figures for 1933.

	1934	1933
Regular Workers—		
(*a*) Males, 21 years old and over	58,700	59,000
(*b*) Males under 21 years old	19,200	19,300
(*c*) Women and Girls	18,000	17,800
Casual Workers—		
(*a*) Males, 21 years old and over	6,800	7,000
(*b*) Males under 21 years old	3,300	3,800
(*c*) Women and Girls	6,100	5,600
Totals	112,100	112,500

	1934	1933
Fowls over six month old	3,810,900	3,742,600
Fowls under six months old	4,239,500	4,351,700
Ducks over " " "	160,600	160,400
Ducks under " " "	85,600	101,900
Geese over " " "	9,300	7,500
Geese under " " "	19,400	19,900
Turkeys over " " "	20,700	18,300
Turkeys under six months old	108,500	111,700
Totals	8,454,500	8,514,000

There is given below a Preliminary Statement, compiled from the returns of varieties of potatoes grown in 1934, of the acreage as at 4th June under the principal varieties, together with the figures for 1933. The acreage accounted for here is 121,300 acres, the remaining 21,700 acres not being included in the returns of varieties. The finally revised figures of acreages under the different varieties of potatoes will be published as usual in October.

	Acres 1934	Acres 1933
First Earlies—		
Duke of York	1,900	1,800
Eclipse	2,100	2,400
Epicure	9,000	9,800
Sharpe's Express	1,800	2,700
Others	1,500	1,200
Totals	16,300	17,900
Second Earlies—		
Ally	300	400
Great Scot	9,300	8,800
British Queen	3,300	3,900
Others	1,600	2,100
Totals	14,500	15,200
Maincrops—		
Arran Banner	2,800	1,800
Golden Wonder	9,000	8,800
Kerr's Pink	40,900	56,700
Majestic	13,800	11,100
Arran Chief	1,900	1,700
King Edward VII.	16,100	14,200
Others	6,000	7,200
Totals	90,500	101,500

CROPS AND GRASS

Distribution	1934	1933	Increase		Decrease	
	Acres	*Acres*	*Acres*	*Per Cent.*	*Acres*	*Per Cent.*
Total Area (excluding Water)	19,069,007	19,069,007	..	..	..	..
Total Acreage under Crops and Grass (*a*) ..	4,599,700	4,613,700	..	..	14,000	0·3
Arable Land	2,995,600	3,030,100	..	..	34,500	1·1
Permanent Grass (*a*) — For Hay	179,100	178,900	200	0·1	..	..
Permanent Grass (*a*) — Not for Hay	1,425,000	1,404,700	20,300	1·4	..	..
Total ..	1,604,100	1,583,600	20,500	1·3	..	..
Wheat	93,000	78,400	14,600	18·6	..	..
Barley (including Bere)	95,000	59,800	35,200	58·9	..	..
Oats	820,000	855,900	..	..	35,900	4·2
Mixed Grain	1,700	1,800	..	..	100	5·6
Rye	3,000	2,800	200	7·1	..	..
Beans (to be harvested as Corn)	2,900	3,000	..	..	100	3·3
Peas	700	600	100	16·7	..	..
Potatoes	143,000	152,500	..	..	9,500	6·2
Turnips and Swedes	353,700	351,700	2,000	0·6	..	..
Mangolds	1,700	1,400	300	21·4	..	..
Sugar Beet	7,500	1,700	5,800	341·2	..	..
Cabbage	5,400	4,800	600	12·5	..	..
Rape	9,700	9,000	700	7·8	..	..
Vetches, Tares, Beans, Peas, Mashlum, etc., for Fodder	8,000	8,400	..	..	400	4·8
Small Fruit	9,200	8,600	600	7·0	..	..
Rye-grass and other Rotation Grasses and Clover — For Hay ..	390,500	391,500	..	..	1,000	0·3
Rye-grass and other Rotation Grasses and Clover — Not for Hay	1,035,000	1,086,000	..	..	51,000	4·7
Total ..	1,425,500	1,477,500	..	..	52,000	3·5
Other Crops	6,300	4,900	1,400	28·6	..	..
Bare Fallow	9,300	7,300	2,000	27·4	..	..

LIVE STOCK

	1934	1933	Increase		Decrease	
	No.	*No.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*
Horses used for Agricultural Purposes (including Mares for Breeding)	112,400	113,900	..	..	1,500	1·3
Unbroken Horses (including Stallions) — One year and above	15,000	14,400	600	4·2	..	..
Unbroken Horses (including Stallions) — Under one year ..	6,000	5,400	600	11·1	..	..
Total ..	133,400	133,700	..	..	300	0·2
Other Horses	15,000	15,800	..	..	800	5·1
Total of Horses ..	148,400	149,500	.	.	1,100	0·7
Cows in Milk	368,000	364,500	3,500	1·0	..	..
Cows in Calf, but not in Milk	54,800	53,500	1,300	2·4	..	..
Heifers in Calf	70,500	65,900	4,600	7·0	..	.
Bulls being used for Service	17,600	17,500	100	0·6	..	..
Other Cattle :—Two years and above	190,800	199,200	..	..	8,400	4·2
,, ,, One year and under two ..	322,500	318,100	4,400	1·4	..	..
,, ,, Under one year	281,500	274,900	6,600	2·4	..	..
Total of Cattle ..	1,305,700	1,293,600	12,100	0·9	..	..
Ewes kept for Breeding	3,350,000	3,385,700	..	..	35,700	1·1
Rams to be used for Service	96,000	95,100	900	0·9	..	..
Other Sheep :—One year and above	927,000	939,400	..	..	12,400	1·3
,, ,, Under one year	3,300,000	3,390,900	..	..	90,900	2·7
Total of Sheep ..	7,673,000	7,811,100	..	..	138,100	1·8
Sows kept for Breeding	27,000	21,900	5,100	23·3	..	..
Boars being used for Service	2,700	2,500	200	8·0	..	..
Other Pigs	170,000	142,600	27,400	19·2	..	..
Total of Pigs	199,700	167,000	32,700	19·6	..	..

(*a*) Excluding Mountain and Heath Land used for grazing.

Agricultural Conditions

Bright, warm and dry weather conditions were general during the first half of June, but showers fell in most districts towards the end of the month with considerable benefit to crops and live stock. Severe frosts caused some damage to crops in north-eastern districts. In Berwick the dry condition of springs entailed much extra work in carting water supplies to stock, while in Wigtown and Kincardine also a scarcity of water was reported. Weather during the first half of July was similar to that of the early part of June; the hay harvest made good progress, but crops suffered, in some districts severely, from the lack of moisture. In the latter part of the month rain fell in all districts, but it came too late to increase appreciably the bulk of straw in cereal crops. Thunderstorms, with heavy and intermittent showers of rain, caused lodging and twisting of grain crops, particularly in the south-east. Grass improved considerably, but in a few districts water was still short, supplies in Wigtown being extremely low at the end of July. Throughout August the weather was broken; rains at times were heavy and much lodging occurred in cereal crops. Bright sunshine and drying winds, however, usually followed the wet spells and grain ripened satisfactorily. The completion of the hay harvest was made rather difficult, and in a few districts, particularly in the Western Islands, the quality of the hay deteriorated.

On the lighter classes of soil wheat was rather thin in places at the end of June, but, on the whole, the crop had a strong, healthy and promising appearance. The rain during the latter part of July helped the filling of the ears and the crop ripened rapidly. Severe lodging by heavy rains occurred in parts of Perth and in Berwick. In the Lothians cutting had begun before the end of July, but in most districts the work was not general until about the middle of August. Some difficulty in cutting was caused by lodging, but wheat generally came to harvest a good, healthy crop, with ears well filled. In eastern districts most of the crop was in stook at the end of August, while in south-western areas a fair proportion of the crop was in the stack. In no district where the crop is grown was the yield expected to be below the normal. In Central Perth, Clackmannan, Kinross, Fife, the Lothians, Roxburgh, Stirling, and Renfrew the yield was expected to exceed the average by 10 per cent., while elsewhere yields varying from average to 5 per cent. above the normal were anticipated.

Barley suffered somewhat from the dry weather conditions early in the season, but showed marked improvement towards the end of June; steady progress was maintained throughout July, and at the end of that month the crop was healthy and ears were filling well. In eastern and north-eastern counties many fields were badly laid and twisted by the heavy rains towards the end of July, great damage being done to some of the best fields in

Roxburgh. Barley ripened well and came to harvest a satisfactory crop. Cutting began in the Lothians during the last week of July, but in most districts the work was not general until the second or third week of August. Much lodging had taken place and on farms in the south-east heavy crops were difficult to handle. The grain was generally of good quality, but in Roxburgh and Selkirk much deterioration occurred through the lodging of the crop. Harvest made fairly good progress, and in North-East Aberdeen most of the crop was in the stackyard by the beginning of September. Estimates of the probable yield indicate that the production will exceed the normal by 10 per cent. in several north-eastern areas and in Kintyre, by from 5 to 10 per cent. in North-East Fife and by 5 per cent. in North-East Aberdeen, South-West Fife, the Lothians, Stirling, and Caithness. In North Argyll, however, the yield was expected to be below the normal by 5 per cent., and in Central Perth, Berwick and Roxburgh by 10 per cent. Elsewhere an average yield was anticipated.

Oats did not thrive so well as the other cereals. Where sown after lea the crop generally made steady progress, but on light land, and where sown after turnips, many fields had not made average progress at the end of July. Plants were, however, healthy, little damage by insect pests was reported, and in most districts the crop was fairly free from weeds. In several areas oats were badly laid and twisted by the heavy rains that fell in the latter half of July. In North Ayr and North and East Perth the harvesting of early varieties had begun before the beginning of August; in early districts in the Lothians and Peebles harvest was practically completed by the end of that month, but elsewhere cutting began about the end of the first week of the month in early fields, and was not general in most districts until the beginning of the third week. Stacking had made fair progress in a few areas, but the broken weather conditions interfered with harvesting and complaints were received of the stooks being very wet at the end of August. Estimates of the probable yield show that the crop will be below the average in bulk. In North-East Banff, Zetland, Central Argyll and Kintyre, however, a yield exceeding the normal by 10 per cent. was expected, while in Orkney, Caithness, and Stirling the excess was estimated at 5 per cent. In Berwick a deficiency of about 20 per cent. was anticipated, in Wigtown and Central Perth 15 per cent., and in North-East Angus, North Argyll, South-East Lanark, North Ayr and Dumfries, 10 per cent. In most other districts the total production was expected to vary between average and 5 per cent. below average.

At the end of July beans were a strong and healthy crop with a good length of straw and had podded well. Plants ripened well during August, and at the end of the month cutting had made good progress in several districts. In Kintyre and Bute it was thought that the yield would exceed the normal by 15 per cent.,

and in North-East Banff, Central and South-East Perth, Clackmannan, Kinross, Fife, Roxburgh, Selkirk and Stirling by 10 per cent.; in North-East Angus and South-East Lanark, however, the yield was expected to be below the normal by 10 per cent. Elsewhere a full average crop was anticipated.

In the Lothians and in parts of the south-western counties early varieties of potatoes were below the average in bulk where lifted before the end of June; tubers were, however, of good quality and free from disease. The rains that fell towards the end of the month were most beneficial to maincrop varieties and plants, although a little backward in several districts, had a promising appearance. Severe frosts caused some damage to plants in Kincardine and parts of Aberdeen and Angus. The moister conditions during the second half of July had a beneficial effect on the crop; good, steady progress was maintained throughout August, tubers swelled well and promised to be of good quality, but in the south-eastern counties prospects for the crop were rather less satisfactory than at the beginning of the month. Some damage by night frosts was reported in Zetland, Leaf Roll was noticeable in various parts of the country, and towards the end of August Blight made an appearance in many districts, but in most cases only to a small extent. At the beginning of September the prospects for maincrop varieties were satisfactory. The yield was expected to be above the average by 15 per cent. in South-West Perth, and by from 5 to 10 per cent. in several eastern and most western districts; in the Lothians, Peebles, Roxburgh, Selkirk, South-East Lanark and Ross it was estimated at 5 per cent. below the normal and in Berwick and South Ayr at 10 per cent. below average.

Turnips and swedes suffered more than any other crop from the dry weather conditions early in the season; second sowings were general in most districts during June, and even third and fourth sowings were carried out. The crop suffered considerably from Turnip Fly during the month and in several areas frost and low night temperatures did more damage than insect pests. When sown early, plants maintained fairly steady growth, but where sown later and particularly where re-sowing was necessary, the crop condition was far below the average at the end of July; in Central, North and East Perth progress was stated to be a month behind the normal, while in many other districts the appearance of the crop was the worst for many years. The rainfall during the latter part of the month helped the development of plants, and in several northern counties, especially in fields near the sea, prospects were quite satisfactory; in Roxburgh and Selkirk, on the other hand, re-sowings were still taking place late in July. In many fields plants had not then come to the hoe, but where singling had been accomplished the crop generally showed a decided improvement. Crows did damage in South-West Angus;

there was evidence of Rot at the neck among early sowings in Kirkcudbright and "Finger and Toe" was rather prevalent in North-East Fife and Dunbarton. In several districts prospects were brighter at the end of August, but the general condition of the crop remained disappointing. In parts of Moray and Banff and in extreme northern and western areas growth was better than elsewhere, particularly where the crop was sown early, but in most eastern and central districts plants did not bulb well, and in several cases the crop was regarded as a total failure. In the Lothians and Peebles turnips in low-lying fields were ruined by green-fly; damage by Rot was apparent in North Ayr, Dumfries and Wigtown, but in Kirkcudbright the Rot noticeable at the beginning of August appeared to have been overcome and the crop was making good progress. The yield of turnips and swedes, as estimated at the beginning of September, was expected to be below the average in bulk by from 5 to 15 per cent. in most districts; in Clackmannan, Kinross, South-West Fife and North-West Lanark the deficiency was estimated at 20 per cent., in Berwick at 40 per cent., and in Central Perth, Roxburgh, Selkirk and Stirling at 50 per cent. In Lewis, however, a yield exceeding the normal by 5 per cent. was anticipated, in Zetland by from 5 to 10 per cent., in Lower Moray, Banff, Kintyre and Bute by 10 per cent., and in Caithness by as much as 15 per cent. Mangolds grew well throughout the season and at the end of August there were prospects of a good, bulky yield in most districts where the crop is grown. The thinning of sugar beet was generally completed by the end of June. Growth was most satisfactory throughout July; plants were strong, healthy and robust at the end of that month and the crop all over was superior to that of last year, owing, in part, to its having been sown earlier than usual on some farms. Some damage was done by Aphis Fly in South-West Angus. At the beginning of September the crop showed prospects of a good yield of roots of fine quality in the principal beet-growing districts. One or two complaints of "bolters" were received, while in the Lothians much damage by green-fly was reported, but plants otherwise were vigorous and healthy, with good tops and satisfactory roots.

The cutting of hay began during the last few days of June, but only in isolated cases or in the earliest districts; in some instances a start was made because of hoeing being held up. Clover appeared to be rather less abundant than usual in several districts, but the mixture improved with the rains towards the end of the month. Excellent harvesting weather was experienced in the first half of July and a good proportion of the crop was then secured. Harvesting was greatly retarded during the latter half of the month by wet weather, and a fair proportion of the crop was still lying in the fields at the beginning of August. Where secured early in July hay was of very good quality but the rain

that came later considerably spoiled the crop in several districts where it had not been put into cole. With grain ripening early in the south-east the completion of the hay harvest was made rather difficult. In a few districts, particularly in the Western Islands, the quality of hay deteriorated through the wet weather during August. In Stirling it was thought that the yield per acre of Timothy was less than last year's by 10 cwt. Estimates of the yield of "seeds" hay received at the beginning of August gave the total production in Orkney as 20 per cent. above the normal; in Zetland and Dumfries the yield was expected to be 15 per cent. heavier than usual, in four other districts 10 per cent. and in six others 5 per cent. In Wigtown a deficiency of 10 per cent. was anticipated, in ten areas 5 per cent.; elsewhere an average crop was expected. In seven districts the yield of meadow hay was thought to be heavier than usual by 10 per cent., and seven others by 5 per cent.; sixteen reports indicated an average yield and ten a deficiency of 5 per cent., while in Berwick and South-East Lanark the crop was expected to be lighter by 10 per cent. and in Wigtown by 15 per cent.

The dry weather during June and the first half of July tended to ripen small fruits before they had swollen properly. Rain during the latter part of July, however, improved the quality of the fruit and at the end of the month crops generally were about average. In South-West Angus the strawberry season was rather short but the fruit was of good quality; in a few areas however the berries were reported to be small. Raspberries suffered less from the dry conditions than did strawberries. In South-East Perth the crop was said to be a record and some difficulty was experienced in getting the picking done in time; from Blairgowrie also an increased tonnage was railed. Currents and gooseberries generally were average crops. In a few districts apple blossom suffered from frost, but at the end of June orchards mostly showed an abundance of flourish and fruits set well. Crops of apples were usually above the average at the beginning of September. Plums were a good crop in Roxburgh, Stirling and Lanark, but in Central and South-East Perth and Dunbarton the crop was below the normal. In Stirling the season for fruit was later than last year by a fortnight.

In most districts during the earlier part of July pastures were becoming rather bare but they improved quickly with the coming of rain. The deficiency of water supplies in June tended to retard the progress of live stock in several districts; in Moray and Banff grass sickness among horses was prevalent and many deaths occurred. Grazing cattle generally made good progress. In the South-East district of Perth stampeding, caused by heat-flies, was reported in June; in July warble-flies were troublesome in East Aberdeen and clegs in Central Perth. In Wigtown "swelling" caused a large number of deaths among dairy cows and in Dun-

barton mastitis was reported among back-calving and newly-calved cows, but stocks otherwise maintained a good, healthy condition. In several districts hand-feeding had to be given to maintain the yield of milk as a result of the drought, but the flow generally was normal for the season of the year. In many areas sheep, both on the hills and on low ground, suffered much from attacks of the maggot fly. Flocks generally throve well when pastures improved.

Stocks of bees maintained a healthy condition and in most cases yields of honey were above the average. Record yields were taken in Central Aberdeen and South-East Perth, but in North-East Perth, Dunbarton, Stirling and North-West Lanark the heather-honey season was disappointing. In North Argyll and Stirling prospects of a good honey season were spoiled by wet weather during August.

Since hay harvesting was not general at the end of June, and turnips were later in coming to the hoe, casual labour was easily obtainable in most districts. In Sutherland and Dunbarton casual labour for hoeing and hay-making was rather scarce in July. In almost every district all available labour had been engaged at harvest time ; in Wigtown there was a fair influx of Irish workers for the harvest, but in Peebles and the Lothians Irish harvesters were very scarce. In Renfrew female dairy workers were short of requirements.

SCIENCE AND PRACTICE

The following extracts and summaries are supplied by members of the staffs of Scottish agricultural colleges and scientific institutions or are taken from recent bulletins of the International Institute of Agriculture. Full references to the original publications may be obtained on application to the Secretary, Department of Agriculture, York Buildings, Edinburgh.

CROPS AND SEEDS

Potato Consumption in the United States. *J. B. R. Dickie, American Potato Journal, Volume* 10, *No.* 6.—The total production of potatoes in the United States of America has averaged about the same for the last twenty years, and although the population of the country has been increasing by over one million per year, there appears to be no increasing demand for potatoes. The habits of diet are changing to a certain extent in nearly all households. The cereal breakfast food is taking the place of fried potatoes on the breakfast table. Southern grown vegetables are now available nearly all winter, and they are being bought and eaten by nearly all classes. The canning industry has expanded greatly within the last fifteen years, and canned vegetables are taking the place of the potato.

It is suggested that commercial growers should inaugurate a campaign to bring the potato more constantly and favourably to the consumer's notice.

The Quality of Wheat as Influenced by Environment. *Frank T. Shutt and S. N. Hamilton. The Empire Journal of Experimental Agriculture, Volume* 2, *No.* 6, *April* 1934.—This paper gives the results of an investigation commenced in 1905 on the influence of seasonal differences on the protein content of wheat.

The value of a wheat for milling purposes is determined by the *amount* and *character* of its protein, commonly known as gluten for this cereal. The character of the gluten appears to be an inherited factor whereas the percentage present may be greatly influenced by environment. In general, soils rich in nitrogen do not influence the composition of the grain, more particularly its protein content. The period of time between the formation

and the ripening of the kernel practically controls the gluten-content of the wheat. High temperatures and absence of excessive moisture during the latter stage of the kernel's development shorten this period, hasten ripening, and result in a high-protein wheat; cool and wet weather in the latter part of the season prolongs the development period, retards ripening, and results in a more or less starchy grain. Although heredity is an influential factor affecting the character of the gluten, it is not the dominant factor in determining the percentage of this constituent stored in the grain. Wheat harvested from soils newly brought into cultivation was decidedly soft, piebald, and of a low protein content; wheat harvested from cultivated soils had a higher nitrogen-content than that grown on soils newly brought into cultivation.

The data collected in this investigation, covering a period of twenty-eight years, and collected at strategic points throughout the Dominion, prove that the excellent quality of the wheat of the prairie provinces was due largely to favourable seasonal conditions, which include high temperatures and absence of excessive moisture during the latter stages of the development of the grain.

Hull-less Seeds of Timothy. *Extracts from a Summary in English of Om "skalade frön" hos timotejen. Nils Sylven. Sveriges Utsädesförenings Argang XXXXIV, Häfte* 1, 1934.—The purpose of this investigation was to elucidate from different viewpoints the practical importance of hull-lessness of timothy, and also to find out if higher or lower percentages of hull-less seeds could be considered as inherited characters in this important grass species. A comparison between individual years' crops of the same clones obviously shows, however, that under all different conditions certain clones are prone to hulling. A thorough investigation of the material disclosed that—at least in extreme cases—special botanical characters of the different timothy types could satisfactorily explain the differences as to the percentage of hull-less seeds. *Witte* (1915) stated that individual timothy varieties showed great differences concerning the attachment of the spikelets to the rachis and the covering of the "seeds" by the lodiculæ. The more difficult it is to disentangle the spikelets from the rachis and the closer the lodiculæ embrace the "seed," the harder the threshing must be done and, consequently, the higher the percentage of hull-less seeds will be. The high percentages of hull-less seeds of the pasture types can, however, be explained in another way. It was found that all pasture types with high-hulling percentages were characterised by specially plump fruits, more or less completely covered by the lodiculæ.

An extensive inbreeding experiment was started at Svälof in 1926 to solve the question of inheritance of these characteristics. The first generation of inbred plants of 1926 showed that the degree of hulling was inherited. It was observed that progenies from easily hulled mother plants as a rule represented types of a high degree of hull-lessness, whereas progenies from mother plants of a low hulling degree had decidedly low-hulling percentages.

Experiments had shown that hulling had an injurious effect upon the germination power of the timothy seeds. In seed lots heavily infected by mildew or *Fusarium* the hull-less seeds deteriorate so fast that even a normal percentage of hull-lessness after a few months can cause economically important losses.

ANIMAL BREEDING

Cattle

The Progeny Testing of Dairy Bulls. *James Mackintosh*, 1934; *Journ. Brit. Dairy Farmers' Assoc., 46*, 11-31.—To Mr James Mackintosh of the National Institute of Research in Dairying at Reading, goes the credit for being the first amongst the more modern of agricultural advisers to advocate the progeny test as a means for the improvement of the productive qualities of our dairy cattle. In 1920 he contributed an article on this point to the *Journal of the Ministry of Agriculture* and illustrated it by the milk yields of the daughters of two bulls, which had been used in the Dairy Shorthorn herd of the University of Reading. This article consists of a presentation and discussion of information on the progeny test collected from the records of the Institute's herd from 1920-1933. Altogether the progeny of four bulls are available for study. The yields were corrected for age, etc.

One important point concerning the results of the various progeny groups of the different bulls is an illustration of the fact realised by many breeders that the rate of maturing of the progeny of one bull is different from that of another. Thus the actual mature yields of the daughters of one bull were some 16 per cent. higher than the yields as calculated by the use of the correction factors. The logical conclusion from these results is that slightly different correction factors should be used for the progeny of each bull. This, however, is impracticable, and the author states that correction factors applied to the first lactation yield of one heifer may be seriously misleading.

Another point of practical importance in the working out of the progeny test is the

number of daughters required to give a reliable indication of the value of a bull. From a statistical point of view, it has been agreed that six daughters constitute the minimum number. The progeny of the various bulls have been grouped, under each bull, in lots of six. With the bull having the largest number of daughters, the first lot gave actual milk yields of daughters amounting to 716 gallons, the second averaged 654, and the third 548. The average for the thirty-two daughters was 618.

With the help of his colleague, Mr Bartlett, the author has attempted to determine the significance of the differences between the average yields of the progeny of the different bulls in the event of comparing the bulls. So far as the milk yields are concerned, the differences between the average of the first sections of six daughters from each bull (given in an accompanying table) might be due to chance, and cannot be taken as convincing evidence that any one bull employed in the herd during this thirteen-year period was definitely superior or inferior to the others. Accordingly, the author states that other qualities possessed by the progeny, such as fat percentage of the milk, shape and wearing qualities of the udder, breed type, etc., would be the deciding factors.

Many consider that the yields of the daughters of a bull depend, to a considerable extent, upon the yields of the cows with which that bull is mated. The results show that the daughters of one bull show an increase of 124 gallons in the actual milk yield of the heifers and of 174 gallons in the mature milk yields over the yields of the dams of these heifers. As regards the heifers' milk yields of the other bulls, decreases are marked, varying from 22 to 88 gallons. The daughters of one other bull had an increase of 48 gallons over that of their dams. The writer concludes that the comparison between the yields of six daughters and that of their dams, while supplying interesting information, is not essential to the interpretation of a progeny test. On the figures stated above there are scientists and breeders who will find it difficult to agree with this conclusion. Much remains to be discovered concerning the progeny test, and Mr Mackintosh is to be congratulated on his contribution to the subject.

Selecting Dairy Cattle. *W. B. Nevans and A. F. Kuhlman*, 1934. *University of Illinois, College of Agriculture, Circ.* 422.—Long experience, combined with detailed study of many animals, is necessary if the farmer is to become proficient in the selection of dairy cattle. While records of milk and butterfat form the most satisfactory index to an animal's productive value, such records are only rarely available, and selection must be based largely on physical appearances. In this Circular emphasis is placed on the selection of dairy animals; illustrations of the animals in the herd of the University of Illinois are shown and the yields of the animals given.

The authors liken the cow to a travelling manufacturing machine which is propelled under its own power. For the greatest returns on the investment, the machine must be so strongly constructed (constitution and health in the cow) that it will continue to perform well over many years. Capacity to use large amounts of the cheapest or most economical fuel (roughage in the case of the cow) is desired. For greatest efficiency, no more weight than is necessary (surplus fat in the cow) should be carried. The manufacturing mechanism which is the delicate part of the machine (the udder in the case of the cow) must have good capacity and not break down after two or three years' use.

Unlike other machines the cow, during a part of the time she is manufacturing milk, is also performing the other valuable function of reproduction.

The writers admit that very few persons can distinguish between cows capable of yielding 400 lb. and 600 lb. or more of butterfat, since both classes of cows possess similar external evidences of good dairy type. Two answers are given to the question as to why breeders should bother about type at all. In the first place, the characters that determine milk production are inherited independently of those that determine body form, therefore production records alone cannot be relied on as a satisfactory guide for the selection of animals in building up a good dairy herd. Second, even if production records could be used as the sole guide, production records of few cows are being kept. Buyers have found that a knowledge of the characters showing dairy type enable them to select good cows.

The rest of the Bulletin is an admirable exposition of the desirable and undesirable points of a dairy cow, particular stress being laid upon the udder and the legs.

Dealing with the words "dairy temperament," the writers state that this means the stimulus to convert the nutrients into milk rather than into body fat. This stimulus is an inherited quality and is found in animals whose ancestors have been bred and selected generation after generation for high milk production. Certain cows with a strong ability to produce milk are at times inclined to produce more milk than is warranted by their feed consumption. Such cows, after calving, usually draw on their body tissues and lose weight. If, at any time, the feed supply is limited, cows with a good dairy tendency use their body tissue for milk and become very thin. Under the same conditions, cows lacking this characteristic tend to reduce their milk flow rapidly and become dry.

A study of the photographs and the records of the cows show that in all breeds a pleasant form and appearance may be combined with high production.

Selection and Management of the Dairy Herd Sire. *G. A. Bowling*, **1933,** *Agric. Exp. Sta., West Virginia, Circ.* 67.—This is a popular account of the principles which govern the selection of the herd sire. Due attention is given to other factors than merely total yield of milk; persistency of production, long life, and proper development of the mammary system are particularly stressed. In this connection there are an interesting series of photographs of the progeny of two bulls. The first bull left his daughters with a distinct improvement in type over their dam, but their average production was much the same. The second bull was plain headed and with an objectionable rump, and passed these characteristics consistently to his offspring. His daughters, however, exceeded the production of their dams by about 200 gallons. Some notes are added concerning the management of aged bulls.

Beef and Dual-purpose Cattle Investigations. 1933. *Report of the Chief of the Bureau of Animal Industry, U.S. Dept. of Agric.*—Record-of-performance studies with beef Shorthorn steers at the United States Animal Husbandry Experiment Farm at Beltsville, Maryland, indicated that there were wide variations among pure-bred strains of Shorthorns in the efficiency with which they utilise their food. The range in time required to reach a finished weight of 900 lb. was from 370 to 503 days. The quantity of beef produced from 100 lb. of total digestible nutrients varied from 14·3 to 22·1 lb. with animals of similar type, fed on the same feeds.

The United States Department of Agriculture are carrying out a fairly large scale investigation into the economy of dual-purpose cattle. There are maintained at Federal and State Stations seven foundation herds of Shorthorns, three of Red Polls, and one of Devons. At each of these Stations the same plan of work is followed, but the feeds used are those which predominate in the locality. The plan is to select the most promising available cattle of the various breeds and, by measuring the performance of their progeny, develop strains of known ability with respect to beef and milk production. The economy of food consumption is also taken into consideration.

The first female of these matings which has completed a year's milk record gave, on two milkings a day, 861 gallons of milk and 342 lb. (4 per cent.) of butterfat. The first eleven steers of these matings show wide variations in the efficiency with which beef is produced. In the time taken to reach a finished weight of 900 lb., they range from 425 to 523 days. The variation in the number of pounds of dressed carcase produced for each 100 lb. of total digestible nutrients eaten was from 14·9 to 18·6. It is significant that one steer, highly efficient in the production of beef, was by the same sire as the heifer mentioned in the previous paragraph, which completed her first lactation so creditably.

Records have been kept of the milk, grain, and alfalfa hay consumed by ten dual-purpose steer calves having an average birth weight of 85 lb. At 505 lb. (weaning time) they had consumed 6·4 lb. of milk per pound of gain in weight, also an average, per steer, of 325 lb. of grain and 383 lb. of hay.

Pigs

Advanced Registry Policy for Pure-bred Swine. *G. B. Rothwell and A. W. Peterson*, 1934. *Dominion Dept. of Agric., Ottawa, Canada.*—A system of pig recording inaugurated in Canada in 1928, appears to be working very well indeed. The policy is, "to provide the swine industry with a system of pig testing organised on a national basis." Individual sows, by means of their progeny, are tested for prolificacy, feeding ability and carcase quality. To a breeder, the value of this policy lies in the knowledge he obtains of the performance of his sows. Since the records are published in detail, particularly as regards the results of the carcases, it is possible for the breeder not merely to eliminate the pigs with low scoring carcases from his herd, but to discover the existence of those other herds which can supply any deficiency in his own. This should be of the greatest value in a constructive breeding policy.

Breeders are required to keep private herd records. Official inspections of the herd are made when the pigs are from four to eight weeks of age. All sows entered, and also their progeny, are then identified by tattooing the ears: the pigs are weighed, and at the same time, nominations are made for the slaughter test. After being reared and finished for market, four of the five pigs nominated by the breeder are shipped to a designated packing plant (Central Slaughter House). The information derived from the carcase test is as follows:—Age in days from birth to slaughter; cold carcase weight; length of side; depth behind shoulder; depth of flank; thickness of back fat at shoulder, loin and thinnest point; weight of shoulders; weight of middle bones; weight of hams; quality and thickness of belly; firmness of fat; grade of carcase.

To qualify, a sow must reach a certain standard in respect of each of the three main factors measured, viz.:—

(1) Production capacity of the sows, *i.e.* fertility and ability to raise a litter;
(2) The capacity of the progeny of the sows for early maturity;
(3) The quality of the progeny as revealed by the slaughter tests.

Boars can qualify by siring at least three litters, the dams of which have qualified as a result of scores secured through such litters. No sow is permitted to complete a slaughter test with pigs from a litter of less than eight, nor with pigs which show a tendency to ridglings, rupture, hermaphroditism, black hair in white breeds, or such like marked disqualifying characters.

As already mentioned, there is published annually an Advanced Registry for pure-bred swine. For the year ending 31st March 1933, this Registry contained the names of some 100 sows in addition to some boars.

It is interesting to note that in the scoring chart the Canadians consider it necessary to include the length of carcase and to divide up the points awarded for back fat into thickness and evenness. In addition to belly measurements, there are a series of measurements in respect of "balance of the side," in which are included the ham, the middle, and the shoulder. The ham must weigh not less than 25 per cent. of the carcase weight, while the shoulder must not exceed 25 per cent. of the carcase weight.

In this country, under the Pigs Marketing Scheme, we are content to grade our pigs solely on the thinness of the back fat and the thickness of the belly. In Canada, in addition to these measurements, the general distribution of the back fat is considered of as great importance as its actual thickness; the length of the carcase is of as great importance as back fat; while balance of side, which includes ham, is of as great value as the belly measurement. The method of grading the ham by a simple weighing measurement is one which ought to commend itself to the Pigs Marketing Board of Great Britain.

Type Studies of Pigs and Economy of Live-weight Gain. 1933. *Report of the Chief of the Bureau of Animal Industry, U.S. Dept. of Agric.*—Work at Beltsville has been on the small, intermediate, and large type of Poland China hogs. In spring 1932, five small-type sows farrowed litters averaging 4·2 and weaned an average of 2·0 pigs. Six intermediate-type sows farrowed an average of 6·7 pigs and weaned 5·8. Five large-type sows farrowed an average of 6·8 and weaned 5·4 pigs. Pigs from the three types of sows were fed in separate groups from weaning to approximately 225 lb. Food was utilised most efficiently by the pigs of large-type parentage. The intermediate and small types followed in order.

Twelve litters of the spring of 1932 and seven litters of fall farrow the same year were tested in connection with performance studies at Beltsville. Four pigs were used to represent each litter. They were on test from 72 days of age until they reached a final weight of approximately 225 lb. The variation in average daily gain for the twelve groups of spring pigs was from 0·56 to 1·41 lb. Feed consumed per 100 lb. gain ranged from 360·7 to 503·6 lb. The seven groups of fall pigs ranged in average daily gain from 0·98 to 1·63 lb., whereas the feed consumed per 100 lb. gain ranged from 336·2 to 396·1 lb. Wide differences in efficiency of production were associated with differences in breeding among the groups. The importance of basing selections of breeding animals on progeny tests is emphasised by these results.

Analysis of data from a series of tests conducted at Miles City, Mont., shows that gilts from gilts farrowed an average of 7·7 pigs, gilts from old sows, 8·9 pigs, and old sows 10·2 pigs. The respective percentages of pigs weaned were 72·7, 76·5, and 61·9. The pigs from each of the three groups of sows were fed under uniform conditions to a market weight of approximately 200 lb. During this feeding period the pigs whose dams were gilts from gilts made an average daily gain of 1·35 lb., those from gilts from old sows 1·43 lb., and those from old sows, 1·40 lb. The respective quantities of feed consumed by the pigs per 100 lb. gain were 382·8, 399·2, and 416·7 lb.

Others factors than those mentioned above are involved in the selection of sows for the breeding herd. However, the results indicate that the use of gilts from gilts is not so satisfactory as the use of the other two groups of sows.

ANIMAL NUTRITION

The Relative Palatability of Seeds-Mixtures, and a Study of the Influence of Fertilisers on Natural Hill Pastures. *W. E. J. Milton. Empire J. Exp. Agric.*, 1934, 2, 51-64. (*Welsh Plant-Breeding Stat., Aberystwyth.*)—Free choice grazing by sheep among plots differently sown with single species or simple seeds-mixtures shows that, although timothy was not the hardest grazed among the pure plots, it formed the basis of the most palatable mixtures. On the mixture plots the sheep appeared to select mixtures as such rather than individual species from mixtures. Red clover, when grown in plots which allow the animal an alternative diet, has a very high palatability.

The effect of manuring with lime or super-phosphate or these combined singly or together with kainit and sulphate of ammonia on three pasture types on hill farms has been examined from the point of view of palatability. Complete manuring yielded the most palatable herbage and the effect of lime was greater than that of super-phosphate.

Feeding Value of Marrowstem Kale. *W. Wöhlbier and W. Schramm. Biedermanns Zentralbl. B. Tierernährung,* 1934, *6,* 1-13. *Agric. Exp. Stat., Rostock i.M.*—Digestibility trials are reported with six sheep on three varieties of marrowstem kale. The digestible protein in the leaves was 3 to 4 times as high as in the stems. The starch value was also higher (by about a fifth) owing to the greater fibre content of the stems. Hence the proportion of leaf to stem is the main factor in evaluation as fodder. The ratio digestible protein-starch equivalent in the leaves is wide and more comparable with that of the leaves of the turnip than of the sugar beet. In the stems the ratio is still wider, but narrower than in the turnips, although the total digestibility of turnips is greater.

Value of Naked Barley as Fodder. *K. G. Schulz. Ztschr. f. Spiritusind.*, 1934, *57,* 2.—As fodder, naked barleys are considerably better than other varieties, as they contain more starch and digestible protein. Pig-fattening tests confirm this conclusion.

Molasses Incorporated in Grain Mixtures. *G. Bohstedt, B. H. Roche, J. M. Fargo, I. W. Rupel, J. G. Fuller, and P. E. Newman. Proc. Amer. Soc. Animal Production,* 1933 (*Jan.* 1934), *52.* (*Univ. Wisconsin.*)—Ten per cent. molasses in grain mixtures for dairy cows, fattening steers and lambs and growing and fattening pigs did not result in significant differences in gains or market production. In all cases except self-fed lambs slightly more feed was required to produce 100 lb. gain on the molasses ration.

Raw Sugar Beet as Feed for Working Horses. *Twelfth contribution to the Practical Application of Scientific Feeding Experiments with Horses. A. Scholz. J. f. Landwirtsch.*, 1933, *81,* 303-354. (*Inst. Agric. Chem. and Bacteriol., Friedrich Wilhelms Univ., Breslau*).—Daily quantities of 24 kg. raw sugar beet, or 6·3 kg. dried beet pulp soaked for a few hours with an equal quantity of water, were fed to working horses (two in each group) for six months with excellent results. One kg. oats can be replaced by 3 kg. raw beet or 1 kg. pulp. Sufficient coarse fodder should be included in the total ration and attention paid to minerals and protein.

Replacement of Oats by Steamed Potatoes in the Feeding of Draught Horses. *G. Engler. Landwirtsch. Jahrb.*, 1933, *78,* 421-496. (*Inst. Agric. Chem. and Bacteriol., Friedrich Wilhelms Univ., Breslau.*)—Two groups of three horses were fed on 6 kg. hay and 2·5 kg. chaff, with 6·5 kg. oats in one case, and 20 kg. steamed potatoes, plus 0·5 kg. soya beans in the other. Dynamometer measurements and digestibility trials were included. The potato-fed horses remained bright, with glossy coats and without digestive disturbance, and it was concluded that 1 kg. of oats could be replaced by 3 kg. of steamed potatoes, plus 0·077 kg. soya bean or other protein-rich supplement.

The Feeding Value of Artificially Dried Young Grass. 2. *O. M. Camburn. Vermont Agric. Exp. Stat., Bull. No.* 359, *June* 1933. (*Burlington, Vermont.*)—Artificially dried young grass fed with two-thirds of the usual allowance of timothy hay and maize silage was compared with grains plus the usual allowance of hay and silage. Whilst the cows on the dried grass maintained their production of milk, fat and solids not fat, their production per pound of digestible nutrients was less than when on the grain ration. This difference was, however, more than accounted for by the gain in body weight of the cows on the dried-grass ration. The dried-grass ration was equal to or slightly better than the grain ration when both milk yield and live-weight increase were taken into account.

Effect of Calcium-deficient Roughages upon Milk Yield and Bone Strength in Cattle. *R. B. Becker, W. M. Neal, and A. L. Shealy. J. Dairy Soc.*, 1934, *17,* 1-10. (*Florida Agric. Exp. Stat., Gainesville.*)—From data accumulated under the conditions of management prevailing over a period of years in the station herd, it was found that the addition of bone meal, as 2 per cent. of the concentrates, to a ration high in protein, energy constituents and phosphorus, but low in calcium, resulted in the case of twelve Jersey cows in an increased milk yield and a more persistent production throughout longer lactation periods. At the same time these cows attained a high stage of mineral storage as evidenced by the increased breaking strength of their bones. Before receiving the mineral supplement many of them had suffered from broken bones.

The Effect of an Iodine Supplement in the Ration of Dairy Cows. *W. Thomson. Vet. J.*, 1934. *90,* 48-51. (*Rowett Res. Inst., Aberdeen.*)—The results are reported of an experiment, conducted over five complete lactations, to test the effect of iodine (90 mg. per head per day) on health, reproduction and milk yield of dairy cows on a good ration. Ten cows received iodine and ten acted as controls. The basal ration was well balanced, but food-stuffs known to be high in iodine were excluded. No fresh green food was fed. Although the number of animals on experiment was small, it is concluded that iodine seemed to assist in maintaining the general health, and as a probable result of this, the milk yield of the cows. Data on contagious abortion indicate a possible role of iodine in the prevention of this disease.

The Relative Value of Cottonseed Meal, Linseed Meal, and Corn-Gluten Meal in fattening Cattle Rations. *A. D. Weber. Proc. Amer. Soc. Animal Production*, 1933 (*Jan.* 1934) 70-72. (*Kansas State Coll.*)—Cottonseed meal, linseed meal, and corn-gluten meals were fed singly and in different combinations at the rate of 1 lb. per day for 145 days to steers weighing approximately 185 lb. to a finished weight of approximately 388 lb. Calves fed linseed-oil meal in general consumed more corn than those fed cottonseed meal or corn-gluten meal, and were generally fatter, had glossier coats and were placed at a higher price. Linseed-oil meal and cottonseed meal were more palatable than corn-gluten meal. Mixtures of linseed meal with corn-gluten or cottonseed meals or all three, equalled or excelled those of a single supplement. Mixed cottonseed meal and corn-gluten meal were equal to linseed meal. Cost should determine which concentrate should be mixed with linseed meal.

The Use of Sugar Pulp in Fattening Cattle. *J. Dept. Agric., Irish Free State*, 1934, *32*, 277-285.—Stall-feeding experiments, involving 147 bullocks and lasting for four seasons (1929-1933) showed that, when a basal ration of roots and hay was supplemented by a mixture of crushed oats, maize meal and decorticated cottonseed meal 2:2:1, "sugar pulp" could be used safely to replace all the maize and part of the oats. "Sugar pulp," of which no analysis is given, was fed so that 11½ lb. replaced 10 lb. maize meal or 11¼ lb. oats. When "sugar pulp" was used in large amounts, up to two-thirds of the concentrates, it was advisable to use linseed cake or some other high-grade oilcake for the last three weeks of fattening. Cattle of 10 to 10½ cwt. are better able to use a ration with a high proportion of "sugar plup," than younger beasts of 8-8½ cwt.

Use of Skimmed Milk in Fattening Young Bullocks. *H. Bünger and A. Werner with J. Schultz and G. Sorge. Biedermanns Zentralbl. B. Tierernährung*, 1934, *6*, 14-49. (*Dairy Res. Inst., Kiel.*)—Thick sour skim milk was willingly taken by young bullocks in quantities up to 10 kg. (sometimes even up to 20 kg.) and stimulated consumption of other foods. In calf rearing the consumption of whole milk should be pushed as rapidly as possible to the feasible limit of about 10 litres at the fourth week, and skim milk then introduced at the period of transition to other foods. It is best given in thick sour form, twice daily, and the supply of other food should not be allowed to retard its elevation to the desired level. The main food should be highly digestible since the sour milk is itself voluminous and acts like moist fodder.

Wool Growth in Sheep as affected by the Carbohydrate Content of the Diet. *A. H. H. Fraser and J. E. Nichols. Empire J. Exp. Agric.*, 1934, *2*, 9-19. (*Rowett Res. Inst., Aberdeen.*)—The addition of 200-500 g. per day of maize starch to a basal maintenance ration in one of two groups of growing sheep resulted in significant increase in body weight and gross fleece weight.

It is suggested that the depression of wool growth in the basal group was due to one or both of two causes: (*a*) the protein of the basal diet might have been used for energy purposes, in which case the added starch in the other group acted as a protein sparer; (*b*) the activity of the wool follicles might have been depressed by the low-energy content of the basal diet. When drought or other famine condition necessitates the supplementary feeding of sheep at pasture, it will be effective and more economical to feed the cheapest available carbohydrate of high caloric value than to use expensive protein supplements.

Skimmed Milk with Potatoes for Fattening Pigs. *W. Stahl and Fr. Haring. Ztschr. f. Schweinezucht*, 1934, *41*, 71-76. (*Res. Stat. Ruhlsdorf, Kr. Teltow.*)—Skim milk and potatoes are both foods with a high water content. From analyses and results of other authorities, 1080 kg. skim milk are equivalent to 100 kg. fish meal, but in the experiments described it was found that skim milk could not replace the whole of the fish meal in a diet for pigs where potatoes were the sole source of carbohydrate food. Four groups of pigs were fed potatoes to appetite together with the following daily rations: (1) 300 g. herring meal; (2) 4 litres skim milk; (3) 6 litres skim milk; (4) 100 g. herring meal+3 litres skim milk. Group 4 gave the best results. 6 litres skim milk was excessive.

The Odour and Flavour of Eggs. *R. B. M'Cammon, M. S. Pittman and L. A Wilhelm. Poultry Sci.*, 1934, *13*, 95-101. (*Kansas Agric. Exp. Stat., Manhattan.*)—Yolk colour was considerably influenced by the ration fed, becoming a deeper colour with yellow corn or green wheat. Eggs produced on a green wheat ration showed little variation in flavour within one month, but all other eggs showed significant variation. Odour was influenced by the nature of the ration and by method of handling. Eggs held at 70° F. for one week showed only slight changes in odour and flavour compared with fresh eggs. Eggs held at this temperature for one month deteriorated.

STATISTICS

PRICES OF AGRICULTURAL PRODUCE, FEEDING STUFFS, AND FERTILISERS IN JUNE, JULY, AND AUGUST 1934.

LIVE STOCK : Monthly Averages of Prices at certain representative Scottish Markets.

(Compiled from Returns received from the Department's Market Reporters)

DESCRIPTION	JUNE			JULY			AUGUST		
	1st Quality	2nd Quality	3rd Quality	1st Quality	2nd Quality	3rd Quality	1st Quality	2nd Quality	3rd Quality
FAT STOCK :—									
*CATTLE—	per cwt. *s. d.*	per cwt. *s. d*	per cwt. *s. d.*	per cwt. *s. d.*	per cwt. *s. d.*	per cwt. *s. d.*	per cwt. *s. d.*	per cwt. *s. d.*	per cwt. *s. d.*
Aberdeen-Angus ..	46 7	42 7	39 2	48 4	44 1	39 1	49 3	44 10	40 5
Cross-bred (Shorthorn)	42 9	38 11	31 11	44 1	40 7	32 3	44 9	41 2	33 2
Galloway	42 2	38 6	..	42 11	39 6	..	42 10	39 11	..
Ayrshire	38 10	34 5	29 0	39 2	35 8	30 3	38 10	35 6	29 3
Blue Grey	47 2	44 3	40 6	45 3	42 4	39 7	46 7	43 4	40 3
Highland	42 6	..	..	..	..	..	..	..	..
	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*
†VEAL CALVES	12	4	..	11¾	4	..	11¾	4	..
†SHEEP—	Hoggs under 60 lb. per lb. *d.*	60 lb. and upw'd. per lb. *d.*	Ewes per lb. *d.*	Hoggs under 60 lb. per lb. *d.*	60 lb. and upw'd. per lb. *d.*	Ewes per lb. *d.*	Hoggs under 60 lb. per lb. *d.*	60 lb. and upw'd. per lb. *d.*	Ewes per lb. *d.*
Cheviot	13½	12½	7½	12¼	11¾	7¼	11¼	11	7¼
Half-bred	12½	12	7¾	11½	11¼	7½	11	10¾	7¼
Blackface	13	12	7¾	11¾	11½	7½	11	10¾	7¼
Greyface	12¾	11¾	7½	12	11	7¼	11¼	10½	7¼
Down Cross	12¾	12¼	6¼	12	11½	5½	11¼	11	5¾
†PIGS—	per stone *s. d.*	per stone *s. d.*	per stone *s. d.*	per stone *s. d.*	per stone *s. d.*	per stone *s. d.*	per stone *s. d.*	per stone *s. d.*	per stone *s. d.*
Bacon Pigs	8 7	7 7	..	8 6	7 8	..	8 6	7 8	..
Porkers	9 2	8 6	..	9 2	8 3	..	9 2	8 3	..

* Live weight. † Estimated dressed carcase weight.

LIVE STOCK: Monthly Averages of Prices (per head) at certain representative Scottish Markets—(*continued*).

Description	June			July			August		
	1st Quality	2nd Quality	3rd Quality	1st Quality	2nd Quality	3rd Quality	1st Quality	2nd Quality	3rd Quality
STORE STOCK:—									
CATTLE—									
Aberdeen-Angus:	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.
Yearlings	14 12	10 16	8 5	14 2	11 4	8 8	14 10	11 10	10 2
Two-year-olds ..	17 8	14 9	10 18	17 13	14 18	11 15	18 8	14 18	11 10
Cross-bred (Shorthorn)									
Yearlings	13 10	10 5	7 3	13 6	10 3	7 17	13 7	10 3	9 2
Two-year-olds ..	16 11	13 7	9 9	16 11	13 17	10 5	17 13	14 11	12 15
Galloway:									
Yearlings	13 3	10 10	..	12 10	10 1	..	12 4	9 6	..
Two-year-olds ..	..	15 5	..	..	..	..	18 0	..	..
Ayrshire:									
Yearlings	11 5	9 14	..	11 3	..	..	10 0	..	..
Two-year-olds ..	13 15	11 15	..	..	..	..	17 0	14 0	11 0
Blue Grey:									
Yearlings	13 10	..	..	..	..	..	..	..	..
Two-year-olds ..	..	..	..	..	..	..	18 0	..	..
Highland:									
Yearlings	8 0	6 17	5 3	..	..	6 3	..	..	..
Two-year-olds ..	10 5	9 8	7 8	..	10 5	8 3	..	..	..
Three-year-olds ..	12 10	11 9	..	..	..	..	..	..	..
DAIRY COWS—									
Ayrshire:									
In milk	24 5	18 17	14 8	24 18	20 0	15 6	25 11	19 17	15 5
Calvers	25 17	19 6	15 4	24 13	19 15	15 13	24 15	19 15	15 12
Shorthorn Cross:									
In milk	25 4	18 13	17 13	25 14	19 12	18 13	26 3	19 18	18 11
Calvers	24 0	17 14	16 8	24 7	18 3	15 14	25 5	18 11	16 9
SHEEP—	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Cheviot Hoggs ..	33 10	27 7	..	..	..	..	..	..	..
Half-bred Hoggs ..	39 0	31 11	..	37 0	26 4	..	41 0	32 6	..
Blackface Hoggs ..	33 7	25 2	..	..	..	..	..	22 6	..
Greyface Hoggs ..	37 11	31 6	..	39 6	31 0	..	..	..	..
Down Cross Hoggs	..	..	..	..	..	..	..	..	..
PIGS—									
(6 to 10 weeks old)	35 9	24 1	..	33 10	22 5	..	32 2	21 2	..

DEAD MEAT: Monthly Average Prices at Dundee, Edinburgh, and Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

Description	Quality	June			July			August		
		Dundee	Edinburgh	Glasgow	Dundee	Edinburgh	Glasgow	Dundee	Edinburgh	Glasgow
		per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.
BEEF :—										
Home-fed—										
Bullock or Heifer ..	1	7¼	7	8	7⅜	7¼	8¼	7¾	7¾	8⅜
	2	6¾	..	7½	7	..	7⅛	7⅛	..	7¾
Bull	1	5½	5⅛	5¾	5¼	5	5⅞	5⅜	5⅛	6
	2	5	..	5⅜	4⅞	..	5⅛	4⅞	..	5¾
Cow	1	5	5⅛	5¼	5	5	5¼	5	4⅞	5¼
	2	4¾	..	4¼	4⅝	..	4⅜	4⅝	..	4⅜
Irish—										
Bullock or Heifer ..	1	..	..	7⅛	..	..	7½	..	..	7¾
	2	..	..	6¼	..	..	6¾	..	..	7⅜
Argentine Frozen—										
Hind Quarters ..	1	4½	4	..	4⅛	4	..	4¼	4	..
	2	..	3½	..	..	3½	..	..	3⅛	..
Fore „ ..	1	3½	3⅛	..	3⅝	3¼	..	3⅜	3¼	..
	2	..	2⅝	..	..	2½	..	..	2⅜	..
Argentine Chilled—										
Hind Quarters ..	1	6¼	6	5¾	5⅞	5⅞	5⅝	6⅞	6⅞	6⅜
	2	..	4⅝	5	..	5⅛	4½	..	5¾	5¾
Fore „ ..	1	3⅞	3¾	3⅜	3¾	3⅝	3⅛	3⅞	4¼	3¾
	2	..	3	3⅛	..	3	2⅞	..	3⅜	..
Brazilian Chilled—										
Hind Quarters ..	1	..	..	4⅛	..	..	4	..	..	5
	2	..	..	4	..	..	3½	..	..	..
Australian Frozen—										
Hind Quarters ..	1	..	..	3⅝	..	..	3¼	..	..	3¼
	2	..	..	..	..	..	..	..	..	..
Crops	1	..	..	2¾	..	..	2⅝	..	..	2⅝
	2	..	..	..	..	..	..	..	..	..
New Zealand Frozen—										
Hind Quarters ..	1	..	..	3½	..	..	3¼	..	..	3¼
	2	..	..	..	..	..	..	..	..	..
Fore „ ..	1	..	..	2¼	..	..	2¼	..	..	2¼
	2	..	..	..	..	..	..	..	..	..
MUTTON :—										
Hoggs, Blackface ..	under 60 lb.	13½	11⅝	12⅝	12¼	11¾	11⅛	11	10¼	10⅞
	60 lb. & over	13	..	12⅛	11¾	..	10⅝	10⅛	..	10⅛
„ Cross ..	under 60 lb.	13½	11⅝	12⅝	11⅞	11¾	11⅛	11	10¼	10⅞
	60 lb. & over	13	..	12⅛	11⅜	..	10⅝	10⅛	..	10⅛
Ewes, Cheviot ..	1	..	7⅜	7⅝	..	7⅛	7½	..	6⅞	6¾
	2	..	..	7⅛	..	..	7	..	..	6⅛
„ Blackface ..	1	9	7⅜	7⅝	8½	7⅛	7½	7¾	6⅞	6¾
	2	8	..	7⅛	7½	..	7	7	..	6½
„ Cross	1	7	7⅜	7⅝	6½	7⅛	7½	6	6⅞	6¾
	2	6	..	7⅛	5½	..	7	5	..	6½
Argentine Frozen ..	1	..	..	3¾	..	..	3¾	..	..	3¾
	2	..	..	..	..	..	..	..	..	..
Australian „ ..	1	..	5⅜	4	..	5½	4	..	5¾	4
	2	..	3¾	..	..	4	..	..	4¾	..
New Zealand „ ..	1	..	..	4¾	..	..	4⅝	..	..	4⅝
	2	..	..	3⅝	..	..	3⅝	..	..	3⅝
LAMB :—										
Home-fed	1	15	12¾	13¾	13¾	12⅜	13	12	11	11
	2	..	..	12⅛	..	..	12¼	..	..	..
New Zealand Frozen	1	..	8	7⅜	..	8⅛	7⅜	..	7⅝	7⅜
	2	..	7	..	..	7	..	..	6¾	..
Australian „ ..	1	..	..	6½	..	..	6⅛	..	..	6⅛
	2	..	..	..	..	..	..	..	..	..
Argentine „ ..	1	..	..	6⅛	..	..	6⅛	..	..	6⅛
	2	..	..	..	..	..	..	..	..	..
PORK :—		per cwt s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt s. d.	per cwt. s. d.	per cwt. s. d.	per cwt. s. d.	per cwt s. d.
Home-fed	1	79 4	72 4	85 2	74 8	68 3	84 0	71 10	70 6	84 0
	2	46 8	..	72 4	46 8	..	72 4	46 8	..	72 4
Imported	1	..	..	56 0	..	..	56 0	..	..	56 0

EGGS: Monthly Average Wholesale Prices at Aberdeen, Kilmarnock, Lanarkshire, and Glasgow.

PROVISIONS: Monthly Average Wholesale Prices (per cwt.) at Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

Description	Weight per 120	Quality	June	July	August
	lb.		s. d.	s. d.	s. d.
Aberdeen—					
Country .. .. per doz.	..	1	0 10	0 10	1 2½
	..	2	0 9¾	..	..
Duck .. .. ,,	..	1	0 11¼	..	..
	..	2	0 10¼	..	..
Kilmarnock—					
Country (ungraded) per doz.	..	1	0 11½	1 1	1 5
Lanarkshire—					
Country "Standard" per doz.	..	1	1 1½	1 3½	1 6
Glasgow—					
National Mark—					
"Special" .. per doz.	..	..	1 1½	1 1½	1 7
"Standard" .. ,,	..	..	1 0½	1 0	1 6
"Medium" .. ,,	..	..	0 10½	0 10½	1 3
"Special" .. per 120	..	..	11 1	11 2	15 6
"Standard" .. ,,	..	..	10 0	10 0	14 7
"Medium" .. ,,	..	..	8 10	8 8	12 6
Northern Ireland ,,	17	..	10 11	11 2	15 4
,, ,,	15½	..	9 10	10 1	14 4
,, (Duck) ,,	..	1	7 9	8 4	10 5
,, ,,	..	2	7 3	..	..
Irish Free State .. ,,	16	..	8 8	8 9	12 1
,, .. ,,	15	..	8 2	8 2	11 7
,, "Medium" ,,	..	..	7 6	7 9	10 3
,, (Duck) ,,	..	1	7 6	7 11	9 11
,, ,, ,,	..	2	7 0	..	..
Danish .. .. ,,	15½	..	8 5	8 5	11 2
,, ... ,,	14	..	7 6	7 11	9 4
Finnish .. .. ,,	15½	..	..	7 8	10 5
,, ... ,,	14	..	6 11	..	8 5
Swedish .. .. ,,	15½	..	..	7 10	10 8
,, ... ,,	14	..	..	6 11	..
Polish .. .. ,,	..	1	5 4	5 10	6 11

Description	Quality	June	July	August
		s. d.	s. d.	s. d.
Butter—				
Irish Creamery	1	81 3	76 6	83 2
,, (unsalted)	1	83 3	79 3	86 2
Australian	1	81 6	76 0	82 2
	2	..	..	..
,, (unsalted)	1	82 0	78 3	..
Danish	1	92 0	89 9	110 0
,, (unsalted)	1	94 6	92 9	113 0
Dutch	1	76 0	74 3	79 6
New Zealand	1	82 9	79 3	85 2
	2	..	..	..
,, (unsalted)	1	84 9	82 0	88 2
Swedish	1	80 6	74 6	86 10
Latvian	1	..	..	76 8
Cheese—				
Cheddar	1	80 0	80 0	58 5
	2	56 0	56 0	46 9
Cheddar Loaf	1	76 0	76 0	..
	2	70 0	..	..
Dunlop	1	80 0	80 0	59 7
	2	56 0	..	49 9
Canadian	1	62 0	62 0	60 5
	2	58 6	60 0	..
New Zealand (Coloured) ..	1	51 0	49 6	50 0
,, (White)	1	52 6	54 6	54 0
Hams—				
Irish (Smoked)	1	152 0	157 0	172 0
	2	132 0	137 9	155 0
American (Long Cut, Green) ..	1	99 0	99 0	99 5
,, (Short Cut, ,,) ..	1	93 0	101 0	101 7
Canadian (Long Cut, ,,) ..	1	99 0	99 0	99 5
Bacon—				
Ayrshire (Rolled)	1	119 0	116 0	125 2
English Wiltshire (Green) ..	1	103 6	101 6	102 2
,, (Dried or Smoked) ..	1	109 6	107 6	108 2
Irish (Green, Wiltshire Style) ..	1	103 0	100 9	103 7
,, (Dried or Smoked) ..	1	111 0	108 0	111 7
,, (Long Clear)	1	112 0	110 6	113 7
Canadian Sides (Green) ..	1	90 0	84 0	90 10
Danish Sides	1	96 6	94 6	100 0
Dutch (Green, Wiltshire Style)	1	111 0	107 3	106 0
Lard—				
American	1	29 3	30 3	34 5

FRUIT AND VEGETABLES : Monthly Average Wholesale Prices at Glasgow.

(Compiled from Returns received from the Department's Market Reporter)

Description		Quality	June	July	August
Fruit :—					
Apples—	per		s. d.	s. d.	s. d.
English Dessert ..	sieve.ø	1	..	..	4 0
„ Cooking ..	barrel.*	1	..	..	7 2
American	case.†	1	..	12 0	13 6
„	barrel.††	1	28 6	28 0	..
Australian	case.†	1	9 10	10 8	13 6
Pears, Californian ..	box.§	1	..	..	17 4
„ Australian ..	case.§	1	16 0	16 0	..
Gooseberries, British ..	lb.	1	0 2	0 1¾	0 2
„ Imported ..	„	1	0 2	..	..
Strawberries, English ..	„	1	0 10½	0 7	..
„ Scottish ..	„	1	..	0 8¼	1 3
Raspberries	„	1	..	0 5¼	0 3¾
Currants, Black	„	1	0 6	0 6¾	0 5
„ Red	„	1	0 6	0 5	0 4¼
Damsons	„	1	..	..	0 2¼
Greengages, Imported ..	„	1	..	..	0 4¼
Plums, Egg	„	1	..	..	0 1¾
„ Prolific	„	1	..	..	0 2¼
„ Victoria	„	1	..	..	0 2¾
Cherries, British ..	„	1	..	0 6	0 6
„ Imported ..	„	1	0 8½	0 6	..
Vegetables :—					
Beans, Dwarf	lb.	1	..	0 5¾	0 4¼
„ Scarlet Runner ..	„		..	..	0 3½
Beet	cwt.	1	3 3	3 0	5 0
Cabbage, Coleworts ..	dozen.	1	1 2	1 0¾	1 0
„ Red	„	1	3 0	..	..
„ Scottish ..	„	1	1 6	1 6	1 4
Carrots, British	cwt.	1	..	11 4	8 5
„ Dutch	„	1	‡3 11	11 9	7 8
Cauliflowers—					
British	dozen.	1	4 2	2 9	3 10
Dutch	„	1	4 0	..	..
Celery	„	1	..	..	1 9
Cucumbers	„	1	5 3	5 3	5 0
Leeks	dozen bunches.	1	2 0	..	2 10
Lettuce, Cos	dozen.	1	..	1 0	1 1
„ Cabbage ..	„	1	1 4	1 0	1 1
Onions, *Spring*	bunch.	1	0 4¾	0 4¼	0 3¾
„ *Dutch*	bag.**		..	..	9 0
„ *Egyptian* ..	cwt.	1	6 2	6 0	..
„ *Valencia* ..	case.††		..	9 4	10 0
Parsley	cwt.	1	9 6	9 0	8 5
Parsnips	„	1	..	..	4 4
Peas	„	1	‖7 8	11 0	14 8
Radishes	dozen bunches.	1	1 4	1 3	1 3
Rhubarb	cwt.	1	2 6	2 5	3 1
Spinach	stone.	1	3 0	3 3	3 0
Tomatoes, Scottish ..	lb.	1	0 7¾	0 5¼	0 5¼
„ Canary ..	„	1	0 3½	..	..
„ Channel Islands	„	1	0 6¼	0 4	0 4
„ Dutch ..	„	1	0 5¾	0 3½	0 4½
Turnips	dozen bunches.	1	5 5	3 5	3 2
Vegetable Marrow ..	dozen.	1	..	..	4 0

ø 20 lb. * 56 lb. † 40 lb. (approx.). †† 9 stone.
§ 46 lb. ‖ 42 lb. ** 7½ stone. ‡ doz. bunches.

POTATOES: Monthly Average Wholesale Prices (per ton) at Aberdeen, Dundee, Edinburgh, and Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

MARKET	Quality	First Earlies	Second Earlies	Late Varieties: Red Soils: Golden Wonder	Late Varieties: Red Soils: Other	Late Varieties: Other Soils: Golden Wonder	Late Varieties: Other Soils: Other
		£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
JUNE							
Aberdeen ..	1	..	..	..	..	3 11 3	2 2 6
Dundee ..	1	13 0 0	..	..	..	3 11 3	2 0 10
Edinburgh ..	1	..	..	..	..	..	..
Glasgow ..	1	18 0 0	1 15 0	..	..	3 10 0	2 1 3
JULY							
Aberdeen ..	1	6 15 0	..	..	..	2 18 4	1 16 10
Dundee ..	1	6 4 8	..	..	..	..	..
Edinburgh ..	1	7 0 0	..	..	..	..	..
Glasgow ..	1	6 7 6	..	..	..	3 0 0	1 15 0
AUGUST							
Aberdeen ..	1	5 16 6	..	..	..	..	..
Dundee ..	1	5 16 0	5 7 6	..	..	..	..
Edinburgh ..	1	6 1 3	5 0 0	..	..	..	..
Glasgow ..	1	6 1 0	5 5 0	..	..	..	..

ROOTS, HAY, STRAW, AND MOSS LITTER: Monthly Average Prices (per ton) at Aberdeen, Dundee, Edinburgh, and Glasgow.

(Compiled from Returns received from the Department's Market Reporters)

MARKET	Quality	Roots: Carrots	Roots: Yellow Turnips	Roots: Swedes	Hay: Rye Grass and Clover	Hay: Timothy	Straw: W	Straw: Barley	Straw: Oat	Moss Litter
		s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
JUNE										
*Aberdeen ..	1	..	..	..	70 0	..	..	..	40 0	..
†Dundee ..	1	..	..	ø15 0	90 0a 80 0b	..	45 0	..	45 0	..
‖Edinburgh ..	1	..	..	..	85 0a 85 0b	..	27 6	..	27 6	..
aGlasgow ..	1	..	..	..	70 0	80 0	35 0	..	37 6	30 10e
JULY										
*Aberdeen ..	1	..	..	..	71 3	..	..	..	36 8	..
†Dundee ..	1	..	..	..	90 0a 80 0b	..	47 6	..	47 6	..
‖Edinburgh ..	1	..	..	..	85 0a 85 0b	..	27 6	..	27 6	..
aGlasgow ..	1	..	..	..	70 0	80 0	35 0	..	37 6	31 0e
AUGUST										
*Aberdeen ..	1	..	..	..	65 0	..	..	..	35 0	..
†Dundee ..	1	..	..	..	87 0a 77 0b	..	50 0	..	50 0	..
‖Edinburgh ..	1	..	..	..	76 6a 76 6b	..	27 6	..	27 6	..
aGlasgow ..	1	..	..	..	74 0	84 0	35 0	..	37 6	33 2e

* Ex farm, loose.
† Baled straw, delivered in town.
ø Delivered in town.
‖ Bunched or baled straw, delivered.
a Baled and delivered.
b Delivered, loose.
e Home moss litter, in 1½-cwt. bales.

FEEDING STUFFS: Monthly Average Prices (per ton) at Glasgow and Leith.

(Compiled from Returns received from the Department's Market Reporters)

Description	June		July		August	
	Glasgow	Leith	Glasgow	Leith	Glasgow	Leith
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Linseed Cake—						
Home	9 3 2	9 0 0	8 18 9	8 17 6	9 7 0	9 3 0
Foreign	8 10 0	7 3 4	7 18 5	7 8 9	8 4 3	8 3 6
Decort. Cotton Cake ..	..	..	6 0 0	..	6 17 3	..
Undecort. Cotton Cake—						
Egyptian (Home manufactured)	4 10 0	4 7 6	4 11 3	4 11 3	5 8 0	5 6 6
Palmnut Kernel Cake ..	7 5 0	.	7 5 0	..	7 1 6	..
Soya Bean Cake	6 10 0	..	6 12 6	..	7 6 6	..
Coconut Cake	7 10 0	..	7 2 6	..	6 6 9	..
Groundnut Cake, undecort.—						
(37 % Oil and Album.) ..	..	..	..	5 0 0	..	5 6 8
(40 % ,, ,,) ..	..	5 12 6	..	5 15 10	..	6 19 5
(50 % ,, ,,) ..	5 12 6	..	5 12 6	6 0 0	6 2 6	..
(54 % ,, ,,) ..	5 12 6	..	5 13 2	..	6 5 8	..
Maize Germ Cake, Home mfd.	6 17 6	..	6 15 11	..	7 0 3	..
Rice Meal	4 5 0	4 1 11	4 15 0	4 10 0	5 4 9	..
Bean Meal	8 0 0	7 15 0	8 1 11	7 15 0	8 17 3	8 7 0
Barley Meal	6 12 2	6 5 0	6 18 5	6 14 5	7 17 3	7 6 0
Fish Meal	14 18 9	14 15 0	15 1 3	14 15 0	15 8 3	15 6 3
Maize Meal—						
Home manufactured ..	5 15 8	5 8 9	5 19 8	5 14 5	7 3 0	6 16 6
Locust Bean Meal	7 15 0	7 0 0	7 15 0	7 0 0	7 15 6	7 1 0
Maize Gluten Feed (Paisley)	4 17 6	..	5 0 4	..	5 15 0	..
Maize—						
Plate	4 18 2	4 14 5	5 1 3	5 1 11	6 5 2	6 3 0
Oats—						
Home	6 7 10	6 3 9	6 19 5	6 13 9	7 6 0	6 10 0
Plate	6 6 11	5 17 6	6 14 1	6 4 5	7 2 11	6 8 4
Barley—						
Imported	5 14 8	5 10 8	6 1 3	6 0 0	7 2 0	6 16 6
Wheat—						
Home	5 18 2	5 12 6	6 2 10	5 15 0	6 16 3	6 12 0
,, (Poultry)	5 12 6	..	5 17 6	..	6 13 3	..
Imported	6 8 9	5 11 3	6 10 0	5 15 8	7 1 6	5 18 9
Middlings (Fine Thirds or Parings)	6 6 3	5 15 0	6 5 11	5 16 11	7 2 3	6 15 0
Sharps (Common Thirds)	5 6 11	5 5 0	5 10 11	5 7 6	6 14 0	6 7 0
Bran (Medium)	5 0 0	4 17 6	5 6 3	5 7 6	6 13 9	6 9 0
,, (Broad)	5 8 9	5 7 6	5 17 6	5 17 6	7 4 0	6 17 6
Malt Culms	4 9 5	4 3 4	4 15 0	4 0 0	5 1 0	4 10 0
Distillers' Mixed Grains (Dried)	..	6 0 0	..	6 6 8	6 7 6	6 0 0
Distillers' Malt Grains (Dried)	5 6 3	..	5 15 4	..	6 9 0	..
Brewers' Grains (Dried) ..	4 18 9	4 1 3	5 3 5	4 7 6	6 1 0	4 19 6
Crushed Linseed	16 0 0	..	16 2 6	..	17 4 0	..
Locust Beans (Kibbled and Stoned)	6 15 8	6 15 0	6 15 0	6 15 0	6 17 0	6 16 0
Beans—						
China	7 5 8	..	7 7 6	7 3 4	..	..
Egyptian	7 3 9	7 5 0	7 3 9	7 10 0	8 1 9	..
Rangoon (Red)	..	5 17 6	..	6 3 9	7 0 0	6 15 0
Persian	7 10 0	..	..	..	..	..
Pease—						
Calcutta (White)	8 8 2	..	..	..	..	..
Karachi (,,)	8 8 2	..	..	..	9 0 0	..
Feeding Treacle	5 5 0	5 10 0	5 5 0	5 10 0	5 5 0	5 10 0
Sugar-Beet Pulp (English) ..	5 7 6	4 15 0	..	..	..	..
Linseed Oil, per gall. ..	0 4 0	..	0 4 0	..	0 4 0	..

FERTILISERS: Monthly Average Prices (per ton) at Glasgow and Leith.

(Compiled from Returns received from the Department's Market Reporters)

Description	Guaranteed Analysis	June Glasgow	June Leith	July Glasgow	July Leith	August Glasgow	August Leith
—	%	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Nitrate of Soda *	N. 15·5	7 18 6	7 18 6	7 18 6	7 18 6	7 14 11	7 13 8
Sulphate of Ammonia (Neutral and Granular) * ..	N. 20·6	7 5 0	7 5 0	7 5 0	7 5 0	6 18 8	6 16 7
Calcium Cyanamide †	N. 20·6	7 5 0	7 5 0	7 5 0	7 5 0	6 19 0	..
Nitrochalk * ..	N. 15·5	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	..
Superphosphate ..	P.A. 13·7	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	..
„ ..	„ 16·0	2 17 6	2 17 6	2 17 6	2 17 6	2 17 6	..
„ ..	„ 18·3	3 2 6	3 2 6	3 2 6	3 2 6	3 2 6	..
Ground Mineral Phosphate ** ..	P.A. 26	2 7 6	2 10 0	2 7 6	2 10 0	2 9 6	..
„ „ „ ** ..	„ 34	3 7 6	3 10 0	3 7 6	3 10 0	3 7 6	..
Potassic Mineral Phosphate	P.A. 18 / Pot. 10	3 16 3	..	3 16 3	..	3 11 3	..
„ „ „	P.A. 18 / Pot. 9	..	3 10 0	..	3 10 0	..	..
„ „ „	P A. 20 / Pot 7.5	3 10 0	..	3 10 0	..	3 6 0	..
„ „ „	P A. 21 / Pot. 5	3 5 0	..	3 5 0	..	..	..
„ „ „	P A. 21 / Pot. 6	..	3 2 6	..	3 2 6	..	..
Kainit (in bags) ..	Pot. 14	3 8 6	3 2 6	3 8 6	3 2 6	§3 5 0	2 18 6
Potash Salts ..	Pot. 20	4 0 0	3 12 6	4 0 0	3 12 6	§3 17 6	3 10 6
„ „ ..	„ 30	5 7 6	4 17 6	5 7 6	4 17 6	§4 12 6	4 7 6
Muriate of Potash (on basis of 80 per cent purity)	Pot. 50	9 5 0	8 15 0	9 5 0	8 15 0	7 6 7	7 7 0
Sulphate of Potash (on basis of 90 per cent purity)	Pot. 48·6	10 12 6	10 0 0	10 12 6	10 0 0	8 9 5	8 0 0
Steamed Bone Flour	N. 0·8 / P.A. 28	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	.
Bone Meal (Indian)	N. 4 / P.A. 20	6 15 0	6 15 0	6 15 0	6 15 0	6 15 0	..
Potassic Slag	P.A. 12 / Pot. 6	..	3 10 0	..	3 10 0	..	
Basic Slag ‡ ..	P.A. 12	2 5 0	..	2 5 9	..	2 5 5	
„ „ ..	„ 13	2 6 0	..	2 6 9	..	2 7 0	
„ „ ..	„ 14	2 8 0	..	2 8 9	..	2 9 0	.
„ „ ..	„ 15	..	2 10 0	..	2 10 0	..	.
„ „ ..	„ 15·75	..	2 12 6	..	2 12 6	..	..

Abbreviations :—N. = Nitrogen; P.A. = Phosphoric Acid; Pot. = Potash.

* Carriage paid, in 6-ton lots. † Carriage paid, in 4-ton lots.

** Fine grist, 90 per cent. fineness through prescribed sieve.

‡ Basic Slag :—At Glasgow—80 per cent. citric soluble and 80 per cent. fineness; f.o.r., in 6-ton lots.
At Leith—80 per cent. citric soluble; on rail, in 2-ton lots.

§ 5s. per ton less if lifted at quay.

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